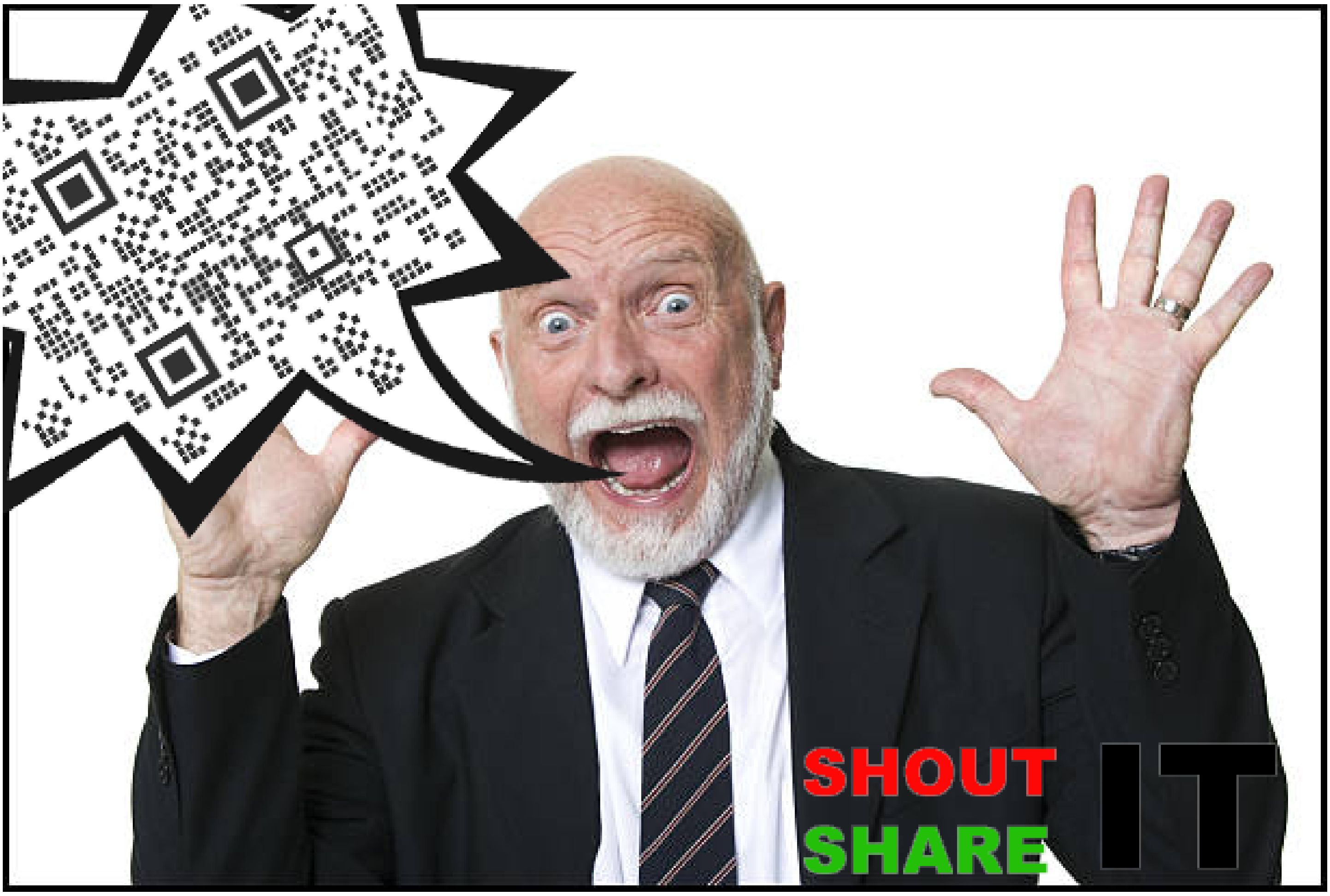
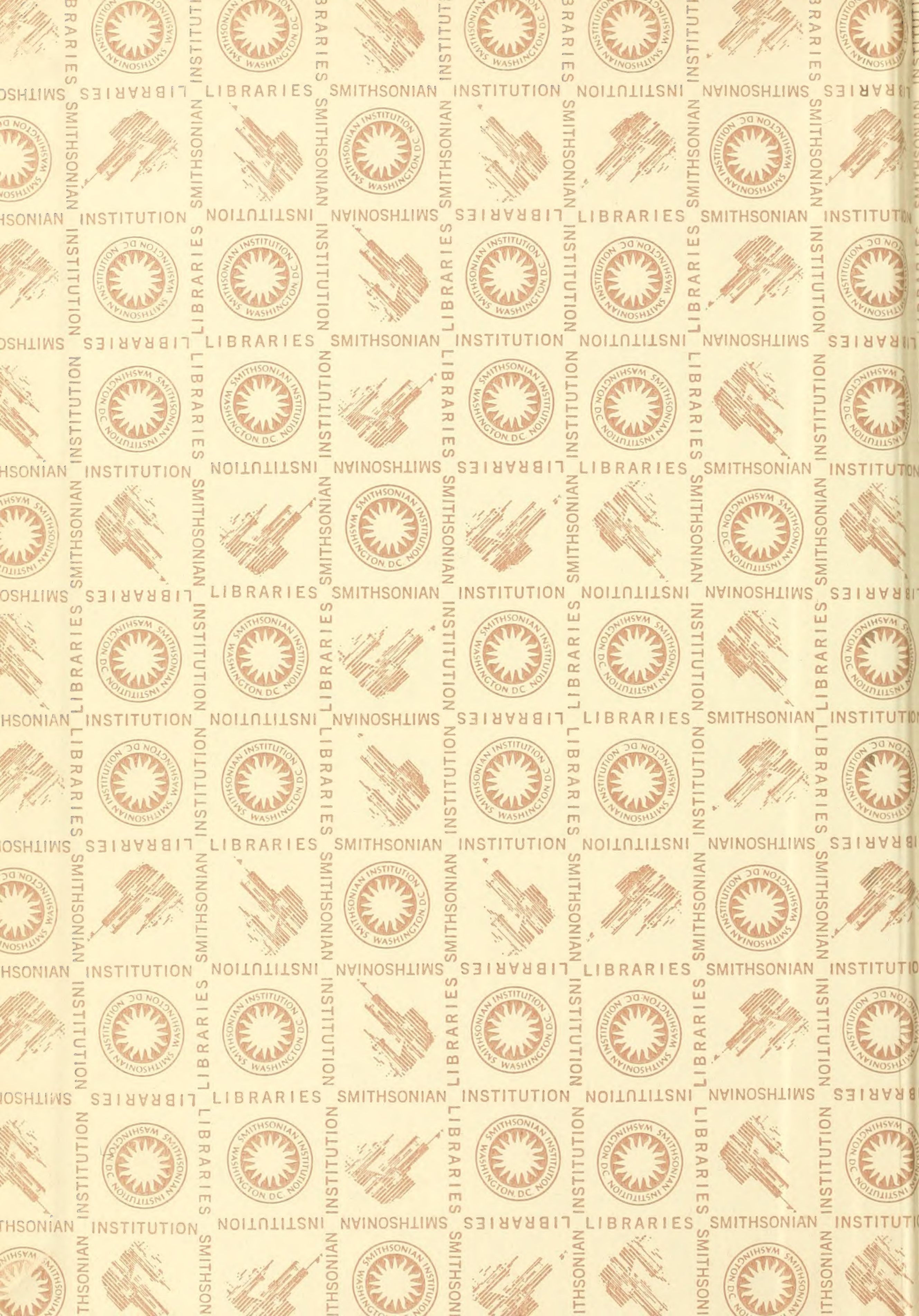

SHOUT
SHARE
IT



SMITHSONIAN INSTITUTION LIBRARIES

SMITHSONIAN INSTITUTION LIBRARIES

SH
11
A2F53
FISH

Division of Fishes,
U. S. National Museum

DEPARTMENT OF COMMERCE AND LABOR

# BULLETIN

OF THE

# BUREAU OF FISHERIES

VOL. XXIV

1904

GEORGE M. BOWERS, Commissioner

WASHINGTON
GOVERNMENT PRINTING OFFICE
1905

√

Smithsonian Institution,
JUL 22 1913
227821
National Museum.

# CONTENTS.

Page.

A revision of Malaclemmys, a genus of turtles. By William Perry Hay. (Issued February 8, 1905.) ........ 1–20

The Medusæ of the Woods Hole Region. By Charles W. Hargitt. (Issued February 14, 1905.) ........ 21–79

The osteology and immediate relations of the tile-fish, Lopholatilus chamæleonticeps. By Frederic A. Lucas. (Issued February 14, 1905.) ........ 81–86

The blood-vascular system of the tile-fish, Lopholatilus chamæleonticeps. By C. F. Silvester. (Issued February 14, 1905.) ........ 87–114

The fish parasites of the genus Argulus found in the Woods Hole Region. By Charles B. Wilson. (Issued February 14, 1905.) ........ 115–131

The seaweed industries of Japan. By Hugh M. Smith. (Issued February 18, 1905.) ........ 133–165

The utilization of seaweeds in the United States. By Hugh M. Smith. (Issued February 18, 1905.) ........ 167–181

The function of the lateral-line organs in fishes. By G. H. Parker. (Issued February 18, 1905.) ........ 183–207

Isopods from the Alaska salmon investigation. By Harriet Richardson. (Issued February 18, 1905.) ........ 209–221

List of fishes collected in Boulder County, Colorado, with description of a new species of Leuciscus. By Chancey Juday. (Issued March 17, 1905.) ........ 223–227

The fish fauna of the Tortugas Archipelago. By David Starr Jordan and Joseph C. Thompson. (Issued May 3, 1905.) ........ 229–256

The cultivation of marine and fresh-water animals in Japan. By K. Mitsukuri. (Issued June 17, 1905.) ........ 257–289

New starfishes from deep water off California and Alaska. By Walter K. Fisher. (Issued June 10, 1905.) ........ 291–320

Parasites of fishes of Beaufort, North Carolina. By Edwin Linton. (Issued October 19, 1905.) ........ 321–428

Physiological studies of the chinook salmon. By Charles Wilson Greene. (Issued November 2, 1905.) ........ 429–456

The amphipoda of southern New England. By S. J. Holmes. (Issued November 8, 1905.) . 457–529

# LIST OF ILLUSTRATIONS.

A REVISION OF MALACLEMMYS, A GENUS OF TURTLES: Facing page.

Plate I. Malaclemmys centrata concentrica ... 3
II. Malaclemmys centrata ... 20
III. Malaclemmys centrata ... 20
IV. Malaclemmys centrata concentrica ... 20
V. Malaclemmys centrata concentrica ... 20
VI. Malaclemmys macrospilota ... 20
VII. Malaclemmys macrospilota ... 20
VIII. Malaclemmys littoralis ... 20
IX. Malaclemmys littoralis ... 20
X. (1) Malaclemmys centrata. (2) Malaclemmys centrata concentrica ... 20
XI. (1) Malaclemmys macrospilota. (2) Malaclemmys pileata ... 20
XII. (1) Malaclemmys centrata, young. (2) Malaclemmys littoralis, young. (3) Malaclemmys littoralis, adult ... 20

MEDUSÆ OF THE WOODS HOLE REGION:

Plate I. (1) Syncoryne producta. (2) Dipurena strangulata. (3) Dipurella clavata. (4) Lizzia grata. (5) Willia ornata ... 80
II. (1) Ectopleura ochracea. (2) Hybocodon prolifer. (3) Hybocodon pendula. (4) Bougainvillia carolinensis ... 80
III. Pennaria tiarella ... 80
IV. (1) Eutima mira. (2) Tima formosa. (3) Eucheilota duodecimalis. (4) Eucheilota ventricularis. (5) Podocoryne carnea ... 80
V. (1) Syncoryne mirabilis. (2) Oceania languida. (3) Epenthesis folleata. (4) Liriope cerasiformis. (5) Charybdea verrucosa ... 80
VI. (1) Gonionemus murbachii. (2) Aurelia flavidula ... 80
VII. (1) Pelagia cyanella. (2) Dactylometra quinquecirra ... 80

BLOOD-VASCULAR SYSTEM OF THE TILE-FISH:

Plate I. (16) Diagram of arterial system. (17) Venous system. (18) First branchial arch ... 114

SEAWEED INDUSTRIES OF JAPAN:

Plate I. Kanten, or seaweed isinglass ... 135
II. The manufacture of funori, or seaweed glue ... 142
III. The manufacture of funori, or seaweed glue ... 144
IV. Views at an Osaka kombu factory ... 150

UTILIZATION OF SEAWEEDS IN THE UNITED STATES:

Plate V. Views of the Irish-moss industry of Massachusetts ... 169

CULTIVATION OF MARINE AND FRESH-WATER ANIMALS IN JAPAN:

Plate I. (1) View of a turtle farm. (2) View in a gold-fish breeder's establishment ... 259
II. (1) Egg deposits of Trionyx covered with wire baskets. (2) Second-year young of Trionyx ... 264
III. (1) Arrangement for collecting young turtles just hatched. (2) Crushing shells for food of turtles ... 266
IV. Varieties of gold-fish ... 268
V. Varieties of gold-fish ... 268
VI. Varieties of gold-fish ... 268
VII. (1) View in carp-culture establishment. (2) Chitose salmon hatchery ... 274
VIII. Oyster grounds ... 278
IX. (1) Spat collectors. (2) "Toya" ground and living ground ... 280
X. (1) General view of Nihojima Inlet, showing oyster grounds. (2) Oyster grounds near Tamsui, Formosa. 282
XI. (1) Culture pearls. (2) "Agemaki" shells ... 286

PARASITES OF FISHES OF BEAUFORT, N. C.:

Plate I. (1–5) Echinorhynchus sagittifer ... 428
II. (6–7) Echinorhynchus sagittifer. (8–11) Echinorhynchus pristis ... 428
III. (12–14) Echinorhynchus pristis. (15–16) Echinorhynchus sp. (17) Filaria galeata ... 428
IV. (18–20) Filaria galeata. (21) Ichthyonema globiceps. (22–23) Ascaris brevicapitata. (24) Heterakis sp. .. 428
V. (25) Heterakis sp. (26–30) Immature nematodes ... 428
VI. (31–35) Immature nematodes ... 428
VII. (36–45) Minute nematodes ... 428
VIII. (46–54) Minute nematodes. (55–56) Sporozoa. (57–58) Parasitic copepod ... 428

PARASITES OF FISHES OF BEAUFORT, N. C.—Continued. Facing page.
Plate IX. (59–66) Rhinebothrium sp. 428
X. (67–71) Rhinebothrium sp. 428
XI. (72–75) Rhinebothrium sp. (76–79) Scolex polymorphus 428
XII. (80) Calliobothrium sp. (81) Blastocyst. (82–84) Larval cestodes. (85–86) Tænia. (87–88) Rhynchobothrium sp. 428
XIII. (89–100) Rhynchobothrium sp. 428
XIV. (101) Rhynchobothrium tenuispine. (102–109) Otobothrium sp. (110–111) Otobothrium crenacolle 428
XV. (112–115) Otobothrium crenacolle. (116–118) Synbothrium sp. 428
XVI. (119–124) Dibothrium tortum 428
XVII. (125) Anthobothrium pulvinatum. (126) Anthobothrium laciniatum. (127) Onchobothrium uncinatum. (128) Acanthobothrium paulum. (129–130) Rhynchobothrium sp. 428
XVIII. (131) Rhynchobothrium sp. (132–138) Rhynchobothrium plicatum 428
XIX. (139–140) Rhynchobothrium plicatum. (141–145) Otobothrium insigne. (146) Rhynchobothrium hispidum 428
XX. (147–150) Microcotyle sp. (151) Dactylocotyle sp. (152–153) Distomum appendiculatum 428
XXI. (154–155) Distomum monticellii. (156–157) Distomum tornatum 428
XXII. (158) Distomum monticellii. (159) Distomum globiporum. (160) Distomum appendiculatum. (161–167) Distomes 428
XXIII. (168–172) Distomes. (173) Distomum globiporum. (174–175) Distomum bothryophoron 428
XXIV. (176–178) Distomum vitellosum. (179) Distomum sp. 428
XXV. (180–182) Distomum corpulentum 428
XXVI. (183–187) Distomum inconstans 428
XXVII. (188) Distomum vibex. (189–194) Distomum imparispine. (195–197) Distomum aduncum 428
XXVIII. (198–199) Distomum globiporum. (200–201) Distomum pectinatum 428
XXIX. (202–203) Distomum pectinatum. (204–209) Distomum sp. 428
XXX. (210–215) Distomum sp. (216) Monostomum sp. 428
XXXI. (217–226) Monostomum sp. 428
XXXII. (227–229) Monostomum sp. (230–232) Gasterostomum gracilescens. (233–234) Gasterostomum baculum. (235) Gasterostomum arcuatum 428
XXXIII. (236–239) Gasterostomum gracilescens. (240–242) Gasterostomum gorgon 428
XXXIV. (243–249) Aspidogaster ringens 428
AMPHIPODA OF SOUTHERN NEW ENGLAND:
Plate I. (1) Hyperia galba. (2) Euthemisto bispinosa. (3) Phronima sedentaria 530
II. (1) Talorchestia longicornis. (2) Talorchestia megalophthalma. (3) Orchestia agilis 530
III. (1) Orchestia palustris. (2) Hyale littoralis. (3) Anonyx nugax 530
IV. (1) Hoplonyx cicada. (2) Hippomedon serratus. (3) Tryphosa pinguis 530
V. (1) Lysianopsis alba. (2) Haustorius arenarius. (3) Byblis serrata 530
VI. (1) Ampelisca compressa. (2) Stegocephalus inflatus. (3) Metopa grœnlandica 530
VII. (1) Leucothoë spinicarpa. (2) Parœdiceros lynceus. (3) Pleustes panoplus 530
VIII. (1) Paramphithoë pulchella. (2) Sympleustes latipes. (3) Epimeria loricata 530
IX. (1) Acanthozone cuspidata. (2) Lafystius sturionis. (3) Eusirus cuspidatus 530
X. (1) Calliopius læviusculus. (2) Gammarellus angulosus. (3) Gammarus locusta 530
XI. (1) Gammarus marinus. (2) Gammarus annulatus. (3) Melita nitida 530
XII. (1) Elasmopus lævis. (2) Mæra danæ. (3) Ptilocheirus pinguis 530
XIII. (1) Amphithoë rubricata. (2) Amphithoë longimana. (3) Ischyrocerus anguipes 530

## TEXT CUTS.

MEDUSÆ OF THE WOODS HOLE REGION: Page.
Perigonimus jonesii 33
Protiara haeckeli 35
Stomotoca apicata, male 35
Stomotoca apicata, female 35
Turris vesicaria 36
Turris episcopalis 36
Turritopsis nutricula 37
Dysmorphosa fulgurans 38
Bougainvillia superciliaris 40
Nemopsis bachei 41
Laodicea calcarata 43
Staurostoma laciniata 43
Orchistoma tentaculata 44
Clytia bicophora 46
Obelia diaphana 48
Tiaropsis diademata 49
Rhegmatodes tenuis 52
Rhopalonema typicum 54
Aglaura hemistoma 55
Aglantha digitalis 55

MEDUSÆ OF THE WOODS HOLE REGION—Continued. Page.

Aglantha conica 56
Glossocodon tenuirostris 57
Ægina pachyderma 58
Solmaris tetranema 58
Diphyes bipartita 59
Diphyopsis campanulifera 60
Sphæronectes gracilis 61
Haliclystus auricula 63
Scyphostomæ of Aurelia flavidula 67
Beroe ovata 73

OSTEOLOGY AND IMMEDIATE RELATIONS OF THE TILE-FISH:

Cranium of Lopholatilus, superior aspect 84
Cranium of Lopholatilus, left lateral aspect 85
Cranium of Lopholatilus, posterior aspect 86

BLOOD-VASCULAR SYSTEM OF THE TILE-FISH:

Efferent branchial vessels of tile-fish, with circulus cephalicus 90
Efferent branchial and head arteries, with circulus cephalicus, in conger eel 91
Cranial portion of arterial system in hickory shad 92
Second efferent branchial artery in hickory shad 92
Fourth efferent branchial artery in hickory shad 92
Efferent branchial vessels of tile-fish, with circulus cephalicus 93
Cranial portion of arterial system in swell-fish 94
Cranial portion of arterial system in sculpin 95
Cranial portion of arterial system in tomcod 97
Cranial portion of arterial system in toad-fish 98
Cranial portion of arterial system in flounder 99
Ventral ends of efferent branchial vessels and their branches in tile-fish 101
Ventral ends of efferent branchial vessels and their branches in tomcod 102
Ventral ends of efferent branchial vessels and their branches in goose-fish 103
Diagrammatic cross section of body of tile-fish 104

FISH PARASITES OF THE GENUS ARGULUS:

Argulus alosæ, female 122
Argulus alosæ, male 122
Argulus catostomi 123
Newly hatched larva of Argulus catostomi 124
A single cluster of eggs of Argulus catostomi 125
A single egg of Argulus catostomi 125
Argulus funduli 126
Argulus laticauda 127
Argulus latus 128
Argulus megalops 129
Newly hatched female larva of Argulus megalops 130
Eggs of Argulus megalops about ready to hatch 130

SEAWEED INDUSTRIES OF JAPAN:

"Tengusa" (Gelidium corneum) 137
Furnace and tub for the boiling of Gelidium 138
Press for straining crude seaweed jelly 139
Pouring liquid kanten into cooling trays 139
Articles used in cutting seaweed jelly into sticks and bars 140
"Funori" (Gloiopeltis coliformis) 144
A roll of funori 145
Kelps used in preparing kombu 147
Kelps used in preparing kombu 147
Forms of hooks used in gathering kelp in Hokkaido 148
Kelp fishermen of Hokkaido 149
Drying kelp on the beach in Hokkaido 150
Gathering kelp with poles and drags 151
Gathering kelp 152
"Amanori" or laver (Porphyra laciniata) 155
Preparing brush for laver cultivation 156
Bundle of brush and conical frame used in planting brush on soft bottom 157
Planting bundles of brush on which laver is to grow 158
Washing laver prior to sorting and cutting 158
Sorting and cutting laver 159
Preparing laver sheets 159
The preparation of Porphyra 160
"Kajime" (Ecklonia cava) 161
"Arame" (Ecklonia bicyclis) 161

UTILIZATION OF SEAWEEDS IN THE UNITED STATES Page.

Irish moss (Chondrus crispus) 170
Dulse (Rhodymenia palmata) 172
Giant kelp (Nereocystis lütkeana) 173
Rockweed (Fucus vesiculosus) 175
Sea lettuce (Ulva latissima) 179
"Badderlocks" (Alaria esculenta) 180
Dulse (Schizymenia edulis) 180

ISOPODS FROM THE ALASKA SALMON INVESTIGATION

Æga symmetrica 212
Rocinela belliceps 213
Rocinela angustata 214
Rocinela propodialis 215
Tole holmesi 217
First incubatory lamella of Bopyroides hippolytes 218
Sixth leg of Bopyroides hippolytes 219
Adult female of Holophryxus alaskensis 221
Maxilliped of Holophryxus alaskensis 221
Terminal segment of first lamella of incubatory plates of Holophryxus alaskensis 221

FISHES FROM BOULDER COUNTY, COLORADO:

Leuciscus evermanni 226

FISH FAUNA OF THE TORTUGAS ARCHIPELAGO:

Holocentrus tortugæ 236
Etelides aquilonaris 241
Eviota personata 251
Gnathypops aurifrons 252
Execestides egregius 253
Execestides egregius, front view 253

CULTIVATION OF MARINE AND FRESH-WATER ANIMALS IN JAPAN:

Plan of a turtle farm 261
Section and plan of a turtle pond 262
Diagram of the tail of a gold-fish 267
"Deme ranchu" 269
Diagram of typical oyster farm, Kaida Bay 279
Diagram of well-developed oyster farm 279
Bamboo collectors for oyster spat 280
Ground plan of a "toya" 281
Map of oyster and seaweed concessions in an estuary of Nihojima 282

PHYSIOLOGICAL STUDIES OF THE CHINOOK SALMON:

Diagram of normal blood pressure from ventral aorta 435
Diagram of a type of blood pressure from ventral aorta when affected by respiratory movements 437
Diagram of blood pressure from ventral aorta showing rhythmic interference of respiratory movements with pulse pressure 438
Diagram of blood pressure from dorsal aorta 441
Diagram showing maximal blood pressure in ventral aorta when that vessel is completely occluded 442
Diagram showing fall in ventral aortic pressure and the irregular heart rate following cutaneous stimulation 443
Diagram showing effect on blood pressure in ventral aorta and on heart rate following stimulation of the vagus nerve 444

AMPHIPODA OF SOUTHERN NEW ENGLAND:

Hyperia galba 464
Talorchestia longicornis 468
Talorchestia megalophthalma 469
Orchestia agilis 470
Orchestia palustris 471
Allorchestes littoralis 472
Anonyx nugax 473
Tryphosa pinguis 473
Hippomedon serratus 474
Lysianopsis alba 475
Pontoporeia femorata 476
Haustorius arenarius 476
Phoxocephalus holbolli 477
Paraphoxus spinosus 478
Ampelisca macrocephala 479
Ampelisca spinipes 480
Ampelisca compressa 481
Ampelisca agassizi 482
Byblis serrata 482
Metopa grœnlandica 483

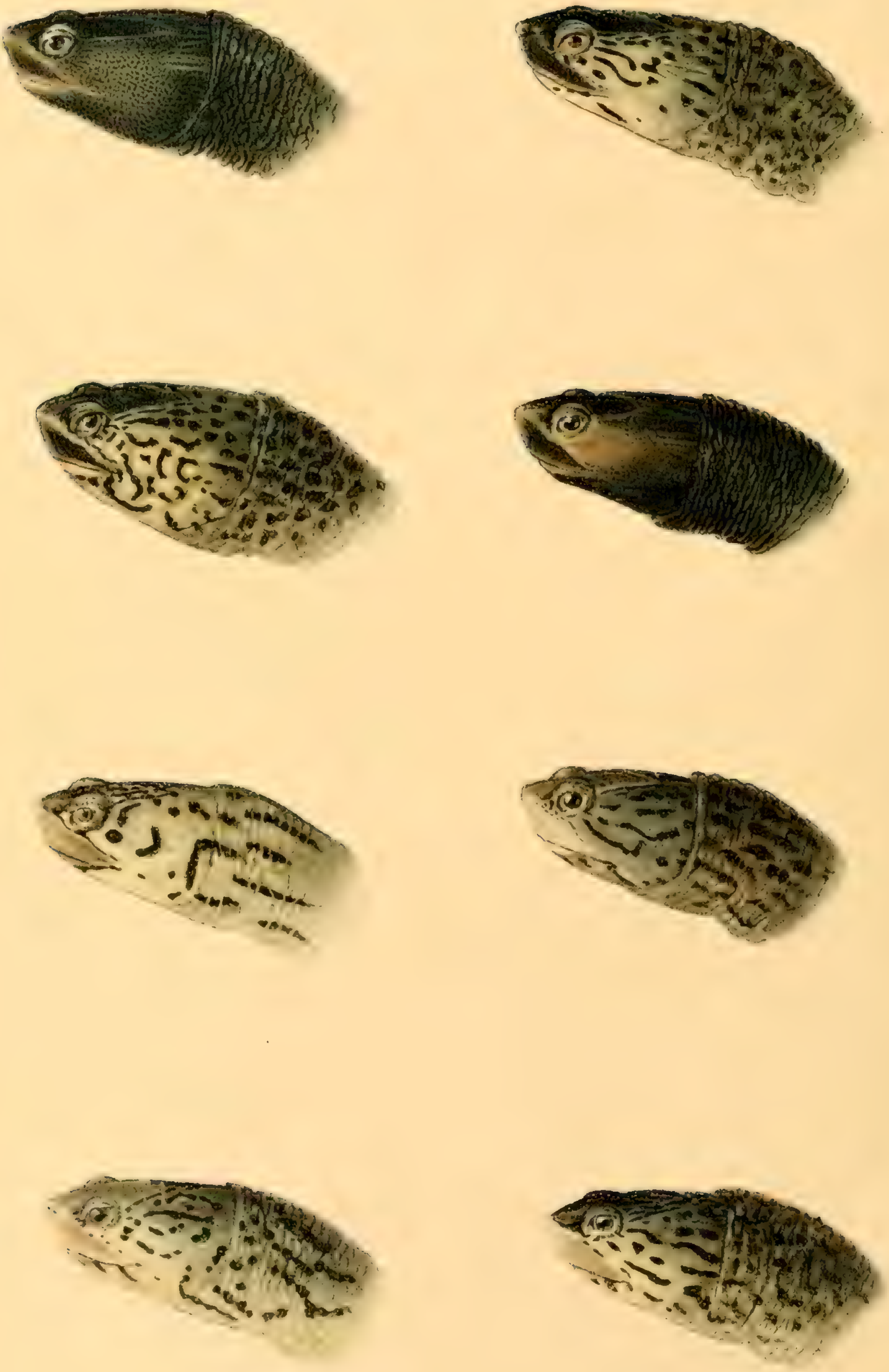
AMPHIPODA OF SOUTHERN NEW ENGLAND—Continued. Page.

Stenothoe cypris ........ 484
Stenothoë minuta ........ 485
Leucothoë spinicarpa ........ 486
Paraediceros lynceus ........ 487
Monoculodes edwardsi ........ 487
Pleustes panoplus ........ 488
Paramphithoë pulchella ........ 489
Sympleustes latipes ........ 490
Sympleustes glaber ........ 491
Acanthozone cuspidata ........ 491
Lafystius sturionis ........ 492
Eusirus cuspidatus ........ 493
Calliopius læviusculus ........ 494
Halirages fulvocinctus ........ 495
Apherusa gracilis ........ 496
Pontogeneia inermis ........ 497
Dexamine thea ........ 498
Batea secunda ........ 499
Gammarus locusta ........ 501
Gammarus annulatus ........ 502
Gammarus marinus ........ 502
Carinogammarus mucronatus ........ 503
Melita dentata ........ 504
Melita nitida ........ 505
Melita parvimana ........ 506
Elasmopus lævis ........ 507
[illegible] ........ 508
[illegible] ........ 509
Amphithoe rubricata ........ 509
Amphithoe longimana ........ 510
Grubia compta ........ 511
Jassa marmorata ........ 512
Ischyrocerus anguipes ........ 513
Microdeutopus gryllotalpa ........ 514
Microdeutopus danmonensis ........ 515
Autonoe smithii ........ 516
Cerapus tubularis ........ 517
Ericthonius rubricornis ........ 518
Ericthonius minax ........ 519
Unciola irrorata ........ 520
Corophium cylindricum ........ 521
Ptilocheirus pinguis ........ 523
Podoceropsis nitida ........ 524
[illegible] ........ 525
Caprella linearis ........ 526

# A REVISION OF MALACLEMMYS, A GENUS OF TURTLES.

By WILLIAM PERRY HAY,
*Professor of Natural History, Howard University.*

PLATE I.



MALACLEMMYS CENTRATA CONCENTRICA

JULIUS BIEN & CO. N.Y.

# A REVISION OF MALACLEMMYS, A GENUS OF TURTLES.

By WILLIAM PERRY HAY,
*Professor of Natural History, Howard University.*

## INTRODUCTION.

During the summers of 1902 and 1903 the writer was engaged in conducting a series of experiments for the Bureau of Fisheries with the object of determining the life history of the diamond-back terrapin and its adaptability to artificial propagation. The field of work covered Chesapeake Bay and its tributary rivers, but the major portion of the time was spent at Solomons Island, a small town at the mouth of the Patuxent River, and at Cristfield, Maryland, the well-known oyster, crab, and terrapin depot on the "Eastern Shore." Both of these localities afford excellent facilities for study not only of the terrapin native to Chesapeake waters, but of those from other localities as well, for certain residents of these towns are extensively engaged in impounding the animals to fatten them for market, for this purpose buying them wherever they can be obtained. There have thus been brought together collections of diamond-back terrapin which are unsurpassed by the collections in any museum, and which have the added advantage of containing living instead of dead specimens.

In addition to the observations in these localities, the markets of Baltimore and Washington have been carefully watched; and the Bureau of Fisheries, through its agents in various southern cities, has secured a number of interesting specimens, from which the accompanying color drawings have been made. Through the courtesy of the American Museum of Natural History I have been enabled to study the terrapin in that collection, including types of Maximilian's *Emys pileata;* and the specimens in the United States National Museum were also placed at my disposal, through the kindness of Doctor Stejneger, who has assisted me in many ways.

An extensive series of photographs made by the writer from the living animals furnishes a part of the illustrations accompanying this paper. The remaining plates are taken from photographs by Mr. R. E. Coker, of the Beaufort (N. C.) laboratory of the Bureau of Fisheries, and from color drawings by Miss E. A. Woodbury; to whom, and to the dealers in terrapin who assisted me in my work, I return grateful acknowledgment, with especial thanks to Mr. J. C. Webster, of Solomons, Maryland, and Messrs. I. H. Tawes, J. H. Riggin, and A. T. Lavallette, of Cristfield, who allowed me to prosecute investigations at their pounds and to study the shipments of terrapin as received.

## GENERIC SYNONYMY AND DIAGNOSES.

The genus *Malaclemmys* was established in 1844 by Gray to receive the species described by Schoepff under the name *Testudo terrapin.*

The synonymy of the genus is as follows:

*Emys*, part, Dum., Zool. Anal., p. 76, 1806.
*Emys*, part, Dum. and Bibr., II, p. 232, 1835.
*Clemmys*, part, Wagler, Syst. Amphib., p. 136, 1830.
*Clemmys*, part, Strauch, Chelon. Stud., p. 28, 1862.
*Terrapene* (not of Merrem), part, Bonap., Osserv. s. sec. Ed. d. R. A., p. 135, 1830.
*Malaclemmys* Gray, Cat. Tortoises, &c., of the Brit. Mus., p. 28, 1844.
*Malaclemmys* Gray, Cat. Shield Rept. I, p. 37, 1855, and Suppl., p. 41, 1870.
*Malacoclemmys* Agassiz, Contrib. Nat. Hist. U. S., p. 437, 1857 (nom. emend.).
*Euchyloclemmys* Sclater, Ann. and Mag. Nat. Hist., I, p. 292, 1858 (name proposed as a substitute for *Malacoclemmys* Agassiz).

The genus is characterized by Boulenger (1889, p. 89) as follows: "Neural plates hexagonal, short-sided in front, plastron extensively united to the carapace by suture, with feeble axillary and inguinal peduncles, the latter anchylosed to the fifth costal plate; entoplastron anterior to the humero-pectoral suture. Skull with a bony temporal arch; alveolar surface very broad, without median ridge; choanæ behind the level of the eyes. Upper surface of head covered with undivided skin. Digits webbed. Tail short. North American." The species included are *M. terrapin* Schoepff, *M. geographica* (Lesueur), and *M. lesueurii* (Gray).

In 1890, Baur (Science, XVI, p. 262, Nov., 1890) added to this list two new species, *M. oculifera* and *M. kohnii*, but later he reestablished the genus *Graptemys* of Agassiz and removed to it *M. geographica*, *M. lesueurii*, *M. oculifera*, and *M. kohnii*, thus leaving *M. terrapin* of Schoepff the only species in the genus *Malaclemmys*.

The examination of the extensive series of diamond-back terrapin which have been available to me shows that instead of one there are at least four well-marked species and one subspecies: *M. centrata* (Latrielle), *M. centrata concentrica* (Shaw), *M. macrospilota* sp. nov., *M. pileata* (Max. zu. Wied), and *M. littoralis* sp. nov. The description of these will be found in this paper.

The genus *Malaclemmys* as recognized here and by Doctor Baur may be characterized as follows:

Emydoid chelonians with the plastron united to the carapace by wide but flat bridge; hind legs stouter than the fore legs and provided with a broad web extending beyond the articulation of the nail joint; distinct scales present only on the legs and feet; inguinal and axillary scales small or wanting; horny sheath of jaws straight, strong, and smooth; alveolar surface flat and broad, without ridges; alveolar margins meeting at an angle in the upper jaw and tapering to a triangle in the lower jaw. All the species are American and inhabit salt marshes along the Atlantic and Gulf coasts.

## BIBLIOGRAPHY OF THE GENUS.

By practically all who in recent years have treated of the genus *Malaclemmys*, only a single species has been recognized, and although most of the authors have spoken of its extreme variability, but few of them have gone so far as to propose names for any of the forms.

The synonymy to be cited is as follows:

*Testudo terrapin* Schoepff, Hist. Test., p. 64, pl. xv, 1792 (not *T. terrapin* Gmel. 1788).
*Testudo terrapin* Schoepff, Naturgesch. der Schildkröten, parts 3 & 4, p. 71, 1793.

*Testudo terrapin* Bechstein, Lacepede's Naturgesch. der Amphib., I, 166, pl. iv, fig. 2, 1800.
*Testudo centrata* Latreille, Hist. Nat. des Rept., I, p. 145, 1802.
*Testudo centrata* Daudin, Hist. Nat. Gen. et Partic. des Rept., II, p. 153, 1803.
*Testudo concentrica* Shaw, Gen. Zool. III, p. 43, pl. ix, 1802.
*Testudo palustris* Le Conte (non Gmel.), Ann. Lyc. N. Y., III, p. 113, 1830.
*Emys centrata* Schweigger, Prodrom. Iconog. Chel., p. 32, 1814.
*Emys centrata* Say, Jour. Acad. Nat. Sci. Phila., Ser. I, IV, p. 205, 1825.
*Emys concentrica* Gray, Synop. Rept., part 1, p. 27, 1831.
*Emys concentrica* Bell, Monograph Test. 1834.*
*Emys concentrica* Duméril et Bibron, Érpétol. Gén., II, p. 261, 1835.
*Emys terrapin* Holbrook, North Am. Herpetol., I, p. 87, pl. xii, 1842.
*Emys terrapin* De Kay, Fauna N. Y., II, pl. xiii, fig. 63, 1842.
*Emys terrapin* Maximilian zu Wied, N. Acta. Acad. Leop. Carol. XXXII, I, p. 16, 1865.
*Emys palustris* De Kay, l. c., p. 10, pl. iii, fig. 5.
*Emys pileata* Maximilian zu Wied, l. c., p. 17, pl. i, figs. 2 & 3, 1865.
*Terrapene palustris* Bonaparte, Osserv. sulla seg. Ed. Cuvier Reg. Anim., p. 157, 1830.
*Malaclemmys concentrica* Gray, Cat. Tort., &c., Brit. Mus., p. 28, 1844.
*Malaclemmys concentrica* Gray, Cat. Shield Rept. Brit. Mus., p. 37, 1855, and suppl., p. 42, 1870.
*Malaclemmys* var. *centrata* Gray, Cat. Shield Rept. Brit. Mus., p. 37, 1855.
*Malaclemmys* var. *tuberculifera* Gray, Cat. Tort., &c., Brit. Mus., p. 28, 1844.
*Malaclemmys* var. *areolata* Gray, Cat. Shield Rept. Brit. Mus., p. 37, 1855.
*Malacoclemmys palustris* Agassiz, Contrib. Nat. Hist. U. S., I, p. 437, pl. i, figs. 10 and 12, pl. 7a, figs. 11–14, 1857.
*Clemmys terrapin* Strauch, Chelon. Stud., p. 132, 1862.*
*Clemmys terrapin* Strauch, Verth. Schildkr., p. 90, 1865.*
*Malacoclemmys terrapen* Boulenger, Cat. Chelon. Brit. Mus., p. 89, 1889.
*Malaclemmys concentrica* Sowerby & Lear, Tortoises, &c., p. 8, pls. xxxiii–xxxvi, 1872.
*Malaclemmys terrapin* Bangs, Proc. Bost. Soc. Nat. Hist. xxvii, 159–161, 1896.
*Malaclemmys centrata* Jordan, Manual of the Vertebrates, 8th ed., p. 209, 1899.

A review of the literature given in the above list, only those works marked (*) having been inaccessible to me, has brought out the following facts, which are presented in full:

1792. Schoepff, J. D.—Historia Testudinum, pp. 64–66, pl. xv.

This author describes "the terrapin" under the name *Testudo terrapin*, and gives three figures of the animal, showing the carapace, plastron, and a front view (the first two figures colored). The habitat is given as North America.[a]

The figure shows a shell which must have come from the northern form, probably from Delaware Bay or northward. The carapace is brown with darker mottlings, and the concentric ridges on the plates are plainly visible. The greatest height is at the 3d vertebral plate. The plastron is light yellow with a large orange blotch and an irregular dusky ring or rectangle on each plate.

Unfortunately Schoepff seems to have been misled by the name *terrapin*, and accordingly regarded his species as identical with the species of Gmelin, which was based on the species described by Brown from Jamaica (Rept. Jamaica) under the name *Testudo terrapin* or *Testudo palustris*. The latter animal has nothing to do with the one in question and belongs to a distinct genus, *Pseudemys*.

1793. Schoepff, J. D.—Naturgeschichte der Schildkröten, Abth. 3 u. 4, s. 71–74.

The description previously cited is given, though in German instead of Latin, with the additional statement that two of the shells upon which the species was based were brought by the author from North America. From the context we may infer that these two shells came from Long Island. The figure shown is the same as in the edition already referred to.

1800. Bechstein, J. M.—Lacepede's Naturgeschichte der Amphibien, I, pp. 166–170, pl. iv, fig. 2.

Under the name *Testudo terrapin* the description of Schoepff is repeated. The plate is a reduced copy of Schoepff's figure, showing the shell from the side.

---

[a] "Habitat in America septentrionali. Duas inde mecum adportavi testas; duas minores misit Rev. Henr. Mühlenberg. *Terrapins* ibidem nuncupari solent, et hoc sub nomine in soris Philadelphiæ, et alibi, venales prostant. Licet capitis et extremitatum cognitione destitutus, aquaticam esse speciem pro certo tamen scio, nam maxima, quam possideo, hujus speciei testa, ex animali in aquis subdulcibus Insulæ Longæ capto, deprompta fuit."

In recentissime epistola, Rev. Mühlenberg sequentia addit: "Habitat in aquis salsis; ad pedis magnitudinem interdum excrescit. Pedes palmati; palmæ 5, plantæ 4-dactylæ, cauda brevis."

1802. LATREILLE, P. A.—Histoire Naturelle des Reptiles, Vol. I, p. 145, pl. VI, fig. 2.

A description of *Testudo centrata*, "la tortue à lignes concentriques." This description was communicated to Latreille in manuscript by Bosc, who had had an opportunity to study the diamond-back terrapin in the neighborhood of Charleston, S. C. It will be noticed that the specific name *centrata* is the earliest acceptable one, and the type locality may be fixed with almost perfect certainty as Charleston, S. C.

1802. SHAW, GEORGE.—General Zoology, vol. 3, pp. 43 and 44.

The author describes under the name *Testudo concentrica* a species which he says is sold in the markets of Philadelphia and elsewhere under the name of terrapin. It is a native of North America and was "apparently first described by Doctor Browne in his Natural History of Jamaica." Characterized as "tortoise with subdepressed, subcarinated, oval, yellow shell, with the scutella marked by concentric brown zones."

A varietal form of the species is figured on Plate IX, the carapace being shown in dorsal view, from "a fine specimen in the Leverian Museum, which is remarkable for having the dark zones on the several pieces of the shell double; being slightly separated by an intermediate line of pale or yellowish ground color." The figure shows the shell of the northern form of *M. centrata*. with the not uncommon character mentioned.

1803. DAUDIN, F. M.—Histoire Naturelle Générale et Particulière des Reptiles, Vol. II, pp. 153–158.

Under the name *la tortue à lignes concentriques*, this author describes a terrapin concerning which in a footnote on p. 153 he quotes as follows: "*Testudo centrata, lineis duabus aut quatuor atris, circulariter centratis, in scutellis loricæ superioris et marginis; sterno flavo immaculato, posticèque marginato.*" Bosc, description manuscrite communiquée.—Latreille, Hist. Nat. des Rept., I, p. 145, pl. VI, fig. 2.

Daudin doubts the validity of the new species, observing that it differs from Schoepff's only in having the plastron entirely yellow. His specimens came from Bosc, who reported them as coming from the sounds of Carolina. He describes three varieties, two based on color differences and one on the divided nuchal plate, but does not name them or assign localities.

1814. SCHWEIGGER, A. T.—Prodromi Iconographiæ Cheloniorum, p. 32.

In this pamphlet occurs the name *Emys centrata*, with references to Bosc, Nouvelle Dictionnaire d'Histoire Naturelle, vol. 22, p. 264, and to Shaw's General Zoology. In the description which follows there is nothing to indicate which form of the terrapin the author was describing except that it was based on six specimens in the Paris Museum and on those of Bosc, which, as before stated, probably came from the neighborhood of Charleston, S. C.

1825. SAY, THOS.—Journal Academy of Natural Sciences of Philadelphia, Ser. I, Vol. IV, p. 205.

In this paper the diamond-back terrapin is described as follows: *E(mys) centrata*. Shell somewhat ovate, carinate excepting on the last plate; plates with concentric circles, either simply colored or deeply impressed; posterior marginal scuta crenate; anterior one quadrate; skin whitish, with very numerous blackish spots; jaws simple.

1830. LE CONTE, J.—Annals of the Lyceum of Natural History of New York, III, p. 113.

Under the name *Testudo palustris*, this paper includes a description of *M. centrata*. The form is not identifiable. Three varieties are mentioned:

*a*. Smooth, with very few concentric striæ. Shell above gray, with concentric marks of black on each plate. Sternum yellow, spots on the skin larger.

*b*. Dark brown, somewhat varied with black; lateral and marginal plates more or less marked with concentric striæ; vertebral plates smooth.

*c*. With concentric striæ on all the plates and black concentric marks on some of them.

The distribution is stated to extend from New York to Florida and even to the West Indies, in salt water and always in the neighborhood of marshes.

1830. BONAPARTE, CARLO LUCIANO.—Testudinum Genera. Sulla Segonda Edizione del Regno Animale del Barone Cuvier Osservazioni di C.-L.-Bonaparte. 1830. Page 157, species 8.

*Terrapene palustris*. The description is in Latin and Italian and refers to *M. centrata* of all forms. The range is stated to extend from New York to Florida.

1831. Gray, John Edward.—Synopsis Reptilium. Part 1. Cataphracta, p. 27.

This author describes *Emys concentrica*, giving references to Bosc in Daudin's Histoire Naturelle des Reptiles, Schoepff, Latreille, Gmelin, and Schweigger. The following forms are described:

*a. livida.* Testa livida obscure annulata, *Emys livida* Bell, Mss.

*b. polita.* Testa margine revoluta, scutellis nigris politis profunde sulcatis, sterno lutescente maculis magnis nigris notatot.

*Junior*, testa carinis continuis scutellis sterni nigro marginatis; cute albido cinereo nigro maculato, capite colloque lineis nigris notatis.

Habit in America Boreali.

Continuing he says: "The head of the living animal is very broad and depressed like the *Hydraspes*, and the neck thick; skin slate colored, black-speckled. In the young specimens the skin is bluish and black-speckled; the forehead is marked with concentric black lines, and there are three curved black lines over each ear; the neck is also marked with short black strokes. The polished variety appears very different, but I have seen specimens which unite it with the common state of the species."

The latter part of this description, at least, undoubtedly applies to some other turtle than the diamond-back, probably to some South American species. The forms described under *a* and *b* are indeterminable, as no localities are assigned, and the descriptions are such as to make it uncertain whether they belong to this species at all.

1834. Bell, Thos.—Monograph of the Testudinata.

No copy of this work has been accessible to me, and I am therefore unable to cite the page or plate referring to the present species. From the fact that four of the plates depicting *Emys concentrica* and intended for this work were published later, by Sowerby and Lear, it is probable that the matter in Bell's Monograph is of little value.

1835. Duméril, A. M. C. et Bibron, G.—Erpétologie Générale ou Histoire Naturelle des Reptiles.

On pp. 261–266, Vol. II, is a detailed description of *Emys concentrica* Gray. The authors regard this species as one of the most variable known to them, and describe three varieties, A, B, and C, based on the colors of the head, neck, legs, shell, and the markings. The material evidently came from numerous localities, and the distribution of the species is given as extending from New York to Florida.

1842. Holbrook, J. E.—North American Herpetology. Second edition, Vol. I, pp. 87–91, pl. xii.

*Emys terrapin* Schoepff. The author gives a detailed description of *M. centrata*, in which he refers to the very large head and the frequent greenish color of the head and shell. The specimens were evidently from South Carolina. The distribution given is from Rhode Island to Florida and the Gulf of Mexico (northern shores), and this species is stated to be the only one common to both North and South America.

The plate gives two views of an animal which is unmistakably the Carolina terrapin, *M. centrata*. The predominating color is greenish; the head is large and heavy.

1842. De Kay, J. E.—Fauna of New York, Part II, pp. 10, 11.

The species figured in plate 23 is the characteristic northern form of *Malaclemmys centrata concentrica*. The concentric markings on the plates of the carapace are strongly brought out. *Emys palustris* and *Emys terrapin* are described, the former being called the "salt-water terrapin" and the latter the "smooth terrapin."

Of *Emys palustris* the author says: "It is well distinguished as the salt-water terrapin, for it is found exclusively in salt or brackish streams near the seashore. They bury themselves in the mud during the winter, from which they are taken in great numbers, and are then very fat. The geographical limits of this species extend from the Gulf of Mexico along the Atlantic to New York. They are found along the northern shores of Long Island to its extremity, but I am not informed whether it occurs on the opposite main shore. Dr. Storer does not mention it in his valuable report on the Reptiles of Massachusetts. The Prince of Canino has introduced this species into Italy, but I have not learned with what success."

Of *Emys terrapin* he says: "I am indebted to Major Le Conte for a figure and note, pointing out the distinctive marks between this and the preceding species * * *. They are brought to our markets at the same time and sold under the common name of *terrapin*. The specimens of the two species of the same size, examined by Major Le Conte, were both females. I had noticed the two, but supposed them to be sexual varieties. The market people say they are caught in the same localities; but as Schöepff derived his specimens (the present species) from Mühlenberg, I am inclined to believe that the *E. terrapin* inhabits indifferently fresh and salt water. Schoepff himself found one on Long Island in water which was almost fresh."

De Kay's conclusions regarding the above species must have been based on insufficient material, or possibly on the really distinct northern and southern forms of *M. centrata*. It would be quite easy at the present day to pick out a dozen individuals in a large series of *M. centrata concentrica* which would differ from each other quite as much as the two specimens just mentioned.

1844. Gray, John Edward.—Catalogue of the Tortoises, Crocodiles, and Amphisbænians in the British Museum, London, p. 28.

*Malaclemmys*.—Generic diagnosis. "Salt-water terrapin, *Maloclemys concentrica*=*Testudo concentrica* of Shaw," etc.

Following this is a description and list of specimens: A, b, c, d, e, f, g, h, and i. Under h is noted, "Shell only (young); the three central vertebral plates with a central tubercle, the hinder tubercle orbicular. *M. tuberculifera*, Gray, B. M. California. Mr. J. Drummond's collection."

As no *Malaclemmys* is known to inhabit any part of North America except the eastern and southern coastal regions it is impossible to say to what the name *M. tuberculifera* refers, although the description fits admirably the young of the species from the Gulf of Mexico; the locality given may be erroneous or the turtle may not be a *Malaclemmys*.

1855. Gray, John Edward.—Catalogue of the Shield Reptiles in the Collection of the British Museum, London, p. 37.

*Malaclemmys*. Generic diagnosis.

*Malaclemmys concentrica*, salt-water terrapin.

Var. 1. *concentrica*. Head black-lined, limbs black-spotted; shield smooth; dorsal and sternal shields with well-defined dark rings.
Var. 2. Not named.
Var. 3. *centrata*. Head black, with small specks, etc.
Var. 4. *tuberculifera*. Characters given in preceding reference. Locality, California.
Var. 5. *areolata*. Head small, back elevated. Central America. Peten.

For varieties 1, 2, and 3 no more definite locality is given than North America, and the distinction is probably based on color variations such as are to be found among any considerable number of these animals. *M. areolata* is too insufficiently described to be identifiable with anything now known, but the record is of interest in that it shows that the genus extends to the neighborhood of Yucatan.

1857. Agassiz, L.—Contributions to the Natural History of the United States, I, pp. 437–438; II, pl. I, figs. 10–12, pl. 7a, figs. 11–14.

Gray's genus *Malaclemmys* is recognized as very distinct, but the name is altered on etymological grounds to *Malacoclemmys*. A single species, *M. palustris*, is mentioned and a short description is given. The range is stated to extend along the Atlantic coast, in salt marshes, from New York to Texas, and even to South America. Specimens from the States bordering on the Gulf of Mexico are said to be generally smaller than those of the Atlantic States and the edge of the carapace is more revolute; but such specimens occur even in the vicinity of New York. In all other respects, also, the species is said to be extremely variable. *Emys areolata* A. Dumeril, it is stated in a footnote (p. 437), was probably based on a specimen with strongly revolute marginal plates, from the Gulf of Mexico.

*Emys macrocephalus* Gray, is said (footnote, p. 438) to have been based on a large-headed variety of *M. palustris* (=*M. centrata*).

Figures show the young and the eggs of *M. centrata*.

1862. Strauch, A.—Chelonien Studien.

This work has not been accessible to me. I therefore cite the page reference given by Boulenger—*Clemmys terrapin*, p. 132.

1865. Strauch, A.—Vertheilungen der Schildkröten.

Like the preceding work, this has not been in my hands, and the reference is Boulenger's—*Clemmys terrapin*, p. 90.

1865. MAXIMILIAN, PRINZ ZU WIED. Verzeichniss der Reptilien welche auf einer Reise in Nördlichen America beobachtet werden; p. 16, pl. 1, figs. 2 and 3.

Contains several paragraphs on *E. terrapin* Schoepff, which are evidently condensations of the more lengthy descriptions of other authorities. The author mentions having seen the animals in the markets of New York and Pittsburg and states that he received in the winter of 1832–33, while at New Harmony, Ind., a lot of nine terrapins from New Orleans which appear to show constant differences from *E. terrapin* of the more northern waters, and which he will describe as *Emys pileata*, "die Emyde mit schwarzen Scheitel." "*E. pileo* nigro splendente; corpore cinereo, maculis nigris; testa immaculata aterrima, margine subtus aurantiaco, subrevoluto." Then follows the description of "an apparently female animal:"

"A thick, rounded emyd, with thick head, massive, strong shell, which, when looked at from above, has a rounded, elliptical form, only slightly convex; somewhat depressed in front and behind; seen from the side, is higher in front than behind; all the marginal plates somewhat revolute, and all the vertebral plates with a strong knob or carina, so that the upper line in profile has almost a saw-toothed appearance. The head of the animal is thick, broad, flat above, very smooth skinned, or covered with a smooth, horny shield, which on the top of the head forms a diamond-shaped surface, and is concave, in so much as the sides of the head are somewhat swollen. The eyes are not prominent. * * * The horny covering of the lips is very wide, extending to just below the eyes. The neck is smooth skinned, of medium length * * * Tail rather short.

"Color: Head and neck ash gray, washed with greenish on the sides of the top of the head. Upper side of neck clear olive brown, but everywhere with small black or dark-brown specks. Legs and body darker gray than the head, everywhere strongly spotted; an olive-yellow streak from the eye to behind the nose (often wanting). A constant character is the black-brown rhomboidal field which covers the top of the head, extending from the nose to the back of the head and from eye to eye. Carapace uniform black, sometimes brown-black, but without any markings except the clear orange on the uprolled marginal plates. The plastron is uniform dusky yellow, or clear gray-yellow, with an occasional clouding of brown or dusky, usually uniform, however. Lips reddish white, claws grayish yellow, hind legs and tail dark gray with the dark speckling obscure, iris olive yellow with small gold specks.

"The male similar, but with a black mustache; plastron clouded with brownish black.

"These emyds occur throughout the Southern States, especially in the salt marshes at the mouth of the Mississippi, near New Orleans, whence they were brought to me alive. They are brought to market by the fishermen, especially the negroes and Indians."

Maximilian thinks that Duméril and Bibron had this species for examination. The plate shows a male with the above characters.

1872. SOWERBY and LEAR.—Tortoises, Terrapins, and Turtles drawn from life by James de Carle Sowerby, F. L. S. and Edward Lear.

A series of plates made under the superintendence of Mr. Thomas Bell to illustrate his Monograph of the Testudinata, but owing to the interruption of that work not published with it. Bell declined to furnish text with these plates and it was supplied by John Edward Gray.

*Emys concentrica*, No. 22, p. 8, pls. XXXIII, XXXIV, XXXV, and XXXVI. The text is of no value. The description is confined to two lines, and then follow quotations from Agassiz and Holbrook. The distribution is stated to be from Rhode Island to Florida, also along the shores of the Gulf of Mexico. "This seems to be the only *Emys* common to North and South America, and it does not appear to be found in the West India Islands."

Pl. XXXIII, a dorsal view of *Emys concentrica; a* represents a rather large-headed form of *centrata*, but with the concentric markings prominent. Female.

Pl. XXXIV represents the under side of the shell only.

Pl. XXXV, dorsal view of *E. concentrica; c* represents an individual with a much-pitted shell. Male.

Pl. XXXVI, dorsal view of *E. concentrica; b* represents an individual probably a Carolina male.

1889. BOULENGER, G. A.—Catalogue of the Chelonians of the British Museum.

On page 89 this author gives a diagnosis of the genus *Malacoclemmys* and describes *M. terrapin.* The full synonymy is the most valuable part of this reference.

1896. Bangs, Outram.—Proceedings Boston Society of Natural History, XXVII, 159-161, Oct., 1896.

Records the occurrence of *M. terrapin* in the headwaters of Buzzards Bay, at Eastham, on Cape Cod. "After careful study we came to the conclusion that the terrapin from the whole Atlantic coast is one species. It is subject to the most extraordinary range of individual variations, however, not only in color, markings, and roughness of shell, but in the more important structural features, such as size and shape of skull, of the horny portions of the mouth and the alveolar region. All these variations are purely fortuitous and do not depend on age, sex, or locality. It is hard to find two terrapin alike." The author does not believe the species was introduced into Buzzards Bay. An 8-inch terrapin, he thinks, is 50 years old.

1899. Jordan, David Starr.—Manual of the Vertebrates, 8th edition, p. 209.

This work contains a short description of *Malaclemmys centrata* Latreille. Under this name all the diamond-back terrapin are included, but the work is of interest as being the first in which the proper combination of generic and specific names occurs.

## GENERAL NATURAL HISTORY.

Diamond-back terrapins, so well known to connoisseurs and purveyors of sea food, are distributed more or less continuously along the eastern coast of North and Central America from Buzzards Bay, Massachusetts, to Yucatan.[a] All the species are lovers of salt or brackish water and find their most congenial homes in low-lying swamps and protected bays or inlets; but they also occur more or less abundantly in nearly all the rivers that empty into the sea within the limits given, and they ascend these rivers to points where the water is quite sweet. In the James River *M. centrata* is found considerably above Jamestown; in the York River it was formerly abundant at West Point; in the Potomac individuals have been taken within 4 miles of Washington.

Of the habits of *M. littoralis*, *M. pileata*, and *M. macrospilota*, absolutely nothing is known except as observed in individuals transported to the pounds near Crisfield, Maryland. Here they act much like *M. centrata*, but go early into hibernation and emerge late in the spring.

The northern species, *M. centrata*, is well known, and its habits have been carefully studied. Its period of hibernation begins soon after the advent of cold weather, but for some weeks it emerges whenever there is a warm day. Eventually, however, it buries itself completely at the bottom of some pool or stream and remains until spring. Very soon after the winter sleep is over it seeks out others of its kind and the process of reproduction begins. Conjugation usually takes place at night or in the very early hours of morning, and always in the water, the diminutive male being carried about on the back of the female. The eggs are laid during May or June, for the most part. For a nest the female, with her hind legs, digs a hole in some convenient bank, and at a depth of 5 or 6 inches deposits from 5 to 12 eggs. She then crawls out, carefully covers up the nest, effaces every trace of her work, and departs. The eggs hatch in about six weeks, if the weather is warm, but may require twice as long if the season is a cold one. The young soon after hatching go to the marsh and dig into the ground, where they spend the first winter and possibly a part of the second summer. The growth is, for a turtle, fairly rapid, the average increase in length being about 1 inch a year until 5 inches or thereabouts is reached, when it becomes slower. Growth probably continues throughout the life of the individual but in old age is so slow as to be almost imperceptible. Twenty-five or thirty years is apparently the limit of life.

---

[a] Their occurrence in Yucatan has been recorded by Gray (1855). It is quite possible that the range extends farther to the southward, but Professor Agassiz's statement that it reaches some point on the coast of South America is not supported by any evidence. The genus *Malaclemmys* does not appear in Cope's list of the reptiles of Mexico.

The food of the diamond-back terrapin consists largely of such crustaceans and mollusks as it is able to catch and crush, but as its jaws are rather weak it is compelled to feed upon the smaller and softer animals of these groups. During exceptionally high tides it sometimes follows the water into the grassy lowlands, and may be seen to catch and eat insects. The tender shoots and rootlets of some of the marsh plants are also eaten, and undoubtedly at times form a very considerable portion of the food. Fresh water seems to be a necessity to the well-being of the diamond-back terrapin, though it can live for a long time without it.

Although it is a common belief in many places where this turtle is found that it is nomadic, moving restlessly from place to place, and that it is able to make considerable journeys in a very short space of time, there is no evidence to support these notions. On the contrary, the individual born in or accidentally transported to a favorable locality probably stays there indefinitely; no other theory will explain the numerous local races and the stories of the reappearance of certain marked terrapins season after season. The former abundance of the diamond-back is a matter of record. At one time hundreds could be seen in a single day where now perhaps only one or two can be found in a season. Thanks to lax laws and ruthless hunters, the species is on the verge of extinction, and before long, unless proper measures are taken, must be numbered among the great host of animals that man has exterminated.

## SEXUAL DIFFERENCES.

The sexual differences in the genus *Malaclemmys*, aside from the genital parts, are greater than in any other group of turtles known to me. The females are much larger than the males, they alone attaining the sizes usually cited in descriptions. Their heads are heavier and less pointed, their bodies deeper, and their tails shorter. The males seldom, if ever, reach a greater length than 5 inches[a]; the shell is flatter

---

[a] Terrapins are usually sold in market by length instead of weight, the measurement being made along the middle line of the lower shell, or plastron, from the lowest point in front to the bottom of the posterior notch. Throughout this paper I follow the popular method of measurement, and such citations of length as are made must be so understood. The length of the carapace exceeds that of the plastron, sometimes slightly, sometimes considerably, varying with the age and the species of the individual; but so far as I have been able to determine the proportion does not possess sufficient constancy to be of value as a character. The following table shows the variations for a number of specimens in this and certain other respects:

| Locality. | Sex. | Bottom shell. | Topshell. | Weight. | Supposed age. |
|---|---|---|---|---|---|
| | | *Inches.* | *Inches.* | *Ounces.* | *Years.* |
| Chesapeake Bay | [illegible] | 4 | [illegible] | 16 | 7 |
| | ♀ | 4 | $4\frac{1}{2}$ | 10 | 5 |
| | ♀ | $4\frac{5}{16}$ | $5\frac{1}{4}$ | 16 | 6 |
| | ♀ | $4\frac{13}{16}$ | $5\frac{5}{16}$ | 16 | 8 |
| | ♀ | $5\frac{3}{4}$ | $6\frac{1}{4}$ | 24 | 6 |
| | ♀ | $6\frac{5}{8}$ | $7\frac{1}{4}$ | 48 | 9 |
| | ♀ | $7\frac{7}{16}$ | $8\frac{1}{4}$ | 48 | 10 |
| | ♂ | $4\frac{3}{4}$ | $5\frac{11}{16}$ | 17 | 6 |
| | ♂ | $3\frac{11}{16}$ | $4\frac{5}{8}$ | 11 | 5 |
| | ♂ | $4\frac{7}{16}$ | $5\frac{3}{16}$ | 15 | 5 |
| North Carolina | [illegible] | [illegible] | [illegible] | 12 | [illegible] |
| | ♀ | $4\frac{1}{2}$ | $4\frac{3}{4}$ | 14 | 7 |
| | ♀ | $4\frac{1}{16}$ | $4\frac{9}{16}$ | 11 | [illegible] |
| | ♀ | $4\frac{15}{16}$ | $5\frac{5}{8}$ | 16 | 5 |
| | ♂ | $4\frac{3}{8}$ | $4\frac{13}{16}$ | 13 | [illegible] |
| Florida | [illegible] | [illegible] | [illegible] | 16 | [illegible] |
| | ♀ | $4\frac{1}{4}$ | [illegible] | 12 | 6 |
| | ♂ | $4\frac{7}{16}$ | [illegible] | ........ | .... |
| Texas | ♀ | 7 | [illegible] | [illegible] | [illegible] |
| | ♀ | $6\frac{9}{16}$ | [illegible] | ..... | 8 |
| | ♂ | $4\frac{11}{16}$ | [illegible] | .... | 8 |

than that of the female, and posteriorly more triangular; the marginal plates are apt to be revolute, the head is smaller, the nose sharper, and the tail longer. All these characters, except the difference in size, are shown in the illustrations accompanying this paper. In the descriptions the female has in every case been placed first, as the material available consists almost entirely of this sex. The laws of several states where the industry is conducted forbid the sale of terrapin less than 5 or 6 inches in length, and therefore only females are caught and sent to market, the males being thrown aside as worthless. Largely on this account the collections of terrapin, in museums as well as in the terrapin pounds, contain very few males. Furthermore, in the pounds the males are thrown together regardless of the locality from which they came. If possible, this sex is more variable than the other and is really not as satisfactory for the purposes of the present paper.

Of the Georgia and the Louisiana terrapins, the writer has not seen perfectly satisfactory male specimens, but males of all the other species have been examined and will be dealt with in their proper places.

### DIFFERENCES DUE TO AGE.

Aside from the natural increase in size and weight the turtles of this genus exhibit some very interesting and important changes in form and sculpture as they advance in age. The young of the northern species, *M. centrata*, and its subspecies resemble the female parent very closely, with the shell perhaps a little rounder and the head proportionally a little larger. The color, however, in every case among the large number I have seen, was a dark blackish-brown, the soft skin being everywhere so thickly speckled with black as nearly to obliterate the ground color. The top of the head and the lips were always dark. The carapace and plastron were more or less flexible and the covering plates, while finely pitted, never showed concentric ridges, and only occasionally the concentric markings so conspicuous in the adult. As the young animal increases in size the plates of the shell are spread apart. To fill the space thus left new shell is developed, underlying the original plates and extending beyond their margins, where it appears in the first year as the first concentric ridge. Presumably this growth takes place periodically, as Agassiz (1857, pp. 260, 290) observed in several species of turtles, and the age of the turtle can be approximated by counting the ridges. For the first six or seven years the growth appears to be quite uniform, the ridges being well separated and usually quite easily counted. Later in life the growth is much slower and the ridges are so close together and so narrow that it becomes impossible to distinguish them. The determination of the age of a very large and old terrapin is rendered still more difficult by the fact that the shell becomes worn off so as to obliterate all but the last-formed ridges. The sexual differences in the young terrapin are apparent after the second or third year.

The striking differences between the young and the adult of the Texas terrapin are described in the paragraphs devoted to that species. Of the Florida species, I have seen individuals ranging from 3½ to 7 inches in length. The very young are still unknown. There is, however, some indication of an increasing roughness of the shell with advancing age up to the fifth or sixth year, when the inevitable wearing away of the older ridges begins.

## MALFORMATIONS.

During my investigations I have met with a very considerable number of specimens of diamond-back terrapin which in one way or another were malformed, either congenitally or as the result of some injury or disease. Malformations of the latter character are of no special interest, except in so far as they show the ability of the animal to recover from its injuries and the futile effort on the part of nature to regenerate the lost parts. In any large collection of terrapin it is easy to find individuals that have lost a foot. Occasionally both the feet on one side or both feet of one pair will be missing and I saw one individual in which all four feet were gone. After such an injury the stump usually heals over smoothly, but occasionally irregular growths, not at all like the missing member, appear, and the result may be a curiously branched, stumpy termination. I have never seen a specimen which showed even an approximately perfect regeneration of any lost part. Injuries to the body, unless too severe, are often survived. One individual I observed in a pound at Crisfield, Md., had lost about one-third of the posterior half of its body, including its left hind leg. The wound, which must have exposed the body cavity, had healed, and the animal was apparently none the worse for the injury.

A disease similar to necrosis of the bone has been observed in a large number of terrapins, especially those confined in pounds. The first appearance of the disease is a small white spot on the plastron. This gradually enlarges, pushing its way through the scale, and a cheesy nodule from the size of a pin head to that of an almond kernel drops out, leaving a more or less deep cavity in the bone. Usually this cavity speedily becomes covered with scar tissue, but in some instances it grows until eventually a large area of the shell is eaten away. In severe cases death results, but I saw one individual which had recovered after more than half the plastron had disappeared. In quite a number of terrapin from South Carolina and in a few from Chesapeake Bay I have found similar cheesy nodules in the skin of the neck and legs. There was always an aperture in the skin, but no amount of pressure could force out the contents. When the tumor was opened a nodule dropped out which on examination showed a concentric structure. The skin surrounding it was considerably inflamed, but there was no suppuration and the wound healed quickly.

The congenital malformations, with one exception, affected the plates of the carapace and were of the most varied character. The most common was the appearance of supernumerary plates, one or more small scales being intercalated among the costal plates. Another, and a very common malformation in one species, was the longitudinal division of the nuchal or the vertebral plates. This seldom led to any rearrangement of the scales, but in one case, on a terrapin from Chesapeake Bay, there was a double series of perfectly formed vertebral plates arranged alternately down the full length of the carapace. The exception mentioned above was a dwarfed animal, which had a very broad and short shell slightly twisted to one side; there was no trace of injury and the terrapin was apparently very old.

## THE AGE THAT TERRAPIN MAY ATTAIN.

Professor Agassiz was of the opinion that most of our turtles, the present species included, may attain a very great age and continue to grow almost indefinitely. It is true that there is almost indisputable evidence to support this assertion in regard to some species, but for nearly all there is a limit, in size at least.

For the diamond-back terrapins the maximum size is about 9 inches, very rarely exceeding 8, and is attained probably at the age of 15 or 20 years. It is quite possible, of course, that the turtles live for many years after attaining their growth, but in this event we should expect to find the plates of the shell worn perfectly smooth, a condition I have never observed in any species except the Texas terrapin, which, probably as a result of the warmer and more uniform climate of its habitat, seems to grow more continuously than its relatives. I am therefore led to believe that from 20 to 25 years is the average duration of life for the turtles of this genus.[a]

## DISCUSSION OF SPECIES.

### *Key to the species and subspecies of the genus Malaclemmys.*

*a.* Carinæ of vertebral plates never tuberculate. Atlantic coast species.
  *b.* Head large to medium size; sides of carapace subparallel; southern form ranging north about to Cape Hatteras ........................................ *M. centrata.*
  *bb.* Head medium to small; carapace widest posteriorly; northern form ranging from about Cape Hatteras to Buzzards Bay ...................... *M. centrata concentrica.*
*aa.* Carinæ of vertebral plates more or less tuberculate, at least in the young. Gulf coast species.
  *c.* Each plate of the carapace with a large central yellow or orange blotch ........ *M. macrospilota.*
  *cc.* Plates of carapace without yellow blotch.
    *d.* Carapace uniform black or dark brown, top of head and upper lip dark ........... *M. pileata.*
    *dd.* Carapace uniform light brown or with traces of concentric markings; upper lip and top of head nearly always white ................................... *M. littoralis.*

**Malaclemmys centrata** (Latreille). The Carolina Terrapin. Pls. II, III, X (fig. 1), and XII (fig. 1).

1802. *Testudo centrata* Latreille, Hist. Nat. des Rept., I, p. 145.
1803. *Testudo centrata* Daudin, Hist. Nat. Gen. et Partic. des Rept., II p., 153.
1814. *Emys centrata* Schweigger, Prodrom. Iconog. Chelon., p. 32.
1825. *Emys centrata* Say, Jour. Acad. Nat. Sci. Phila., IV, p. 205 (part).
1830. *Terrapene palustris* Bonaparte, Test. Gen., p. 157.
1830. *Testudo palustris* LeConte, Ann. Lyc. N. Y., III, p. 113 (part).
1831. *Emys centrata* Gray, Synopsis Rept., pt. 1, p. 27 (part).
1834 *Emys concentrica* Bell, Monog. Test. (part?). (This work not examined).
1835 *Emys concentrica* Dumeril & Bibron, Érpétol. Gén., p. 261 (part).
1842. *Emys terrapin* Holbrook, North Am. Herp., I, p. 87, Pl. XII (part).
1842. *Emys terrapin* DeKay, Fauna N. Y., II (part).
1844 *Malaclemmys concentrica* Gray, Cat. Tort. &c., Brit. Mus., p. 28 (part).
1857. *Malacoclemmys palustris* Agassiz, Contr. Nat. Hist. U. S., I, p. 437, pls. 1 and 7a (part).
1862 *Clemmys terrapin* Strauch, Chelon. Studien, p. 132 (part?), not examined.
1865 *Clemmys terrapin* Strauch, Vertheil. Schildkr., p. 90 (part?), not examined.
1865 *Emys terrapin* Maximilian, N. A. Acad. Leop. Carol., XXXII, I, p. 16.
1889. *Malacoclemmys terrapen* Boulenger, Cat. Chelon. Brit. Mus., p. 89 (part).
1899. *Malaclemmys centrata* Jordan, Man. Vert. 8th ed., p. 209 (part).

*Type locality.*—Bosc's material, on which Latreille's description was based, probably came from the neighborhood of Charleston, South Carolina.

*Distribution.*—Littoral region of the eastern United States from the neighborhood of Cape Hatteras southward to the coast of Florida.

*Characters.*—When looked at from above, the shell of this terrapin is ovoid in outline, the greatest width being behind the middle and across the fourth vertebral plate; the front is not very deeply, sometimes scarcely at all, notched. From the side view the shell is seen to be highest near the middle, the tops of the crests of the second and third vertebral plates usually being the highest points, from which the curve downward is gradual, both backward and forward; the lower margin of the carapace slopes gently downward from the front to a point near the suture between the seventh and eighth marginal plates, then flares upward and outward a little and descends again behind; vertical and horizontal measurements of the marginal plates above the bridge—the fifth, sixth, and seventh—approximately equal; edges of marginal plates from the sixth backward often sharp and conspicuously revolute; inguinal and axillary plates may be well developed or small, or one of them may be wanting; keels of vertebral plates rather low and rounded, those of the third and fourth only being at all trenchant; plates of the carapace usually concentrically ridged, although in large individuals they are apt to be almost perfectly smooth. The plastron is comparatively broad, slightly notched or truncate in front, thence curving outward and backward to the bridge; behind the bridge the sides of the plastron are subparallel to the posterior margin of the femoral plate, where there is a prominent notch, and are then rather strongly convergent to the ends of the anal plates, between which, on the median line, there is a rather deep notch; epidermal plates of the plastron usually smooth.

---

[a] In this connection see Bangs (1896), in which article the occurrence of *M. centrata* ("*M. terrapin*") in Buzzards Bay, Massachusetts, is recorded and remarks are made on the variations observed in a large series of the species.

The head is large and heavy, its sides behind the eyes being more or less swollen; nose short and blunt; jaws strong and provided with a broad horny covering; eyes somewhat prominent, but not so markedly so as in the species from the Gulf of Mexico.

The legs and feet are strong, provided with stout claws; hind feet broadly webbed. Tail short and weak.

The male differs very markedly from the female in the shape of the carapace; the margins from a little behind the bridge to near the posterior end of the shell are nearly straight, so that they meet at an angle instead of together forming an arc; the marginal plates from a little in front of the bridge to the posterior end are nearly always strongly revolute. The head is proportionally much smaller and lacks altogether the heavy, blunt appearance just described in the case of the female; the tail is longer and stronger.

The coloration is extremely variable and offers no diagnostic characters of value. A series of 85 terrapin from Enterprise, North Carolina, showed the following variation: 13 females, 5 inches long and under (measured on the middle line of the plastron), ranged from rather light slate-green individuals, very slightly marbled with darker, to some in which the scales of the carapace were black with more or less wide slate-green margins; the plastrons ranged from a rather pronounced orange yellow, through honey yellow, to greenish gray; in some cases the plastrons were uniformly colored, in others they were more or less blotched or clouded with dusky; the lips were white and the top of the head was white or light greenish. Eight females, 5 inches long and under, had the carapace entirely black and the plastron yellow orange much blotched and clouded with black; the upper lip and the top of the head were black, and the skin of the neck, legs, and tail was gray-green with many short crooked black lines and small specks. Five females, of about the same size as those just mentioned, were almost perfectly intermediate in coloration, having brownish carapaces with more or less strong traces of green marbling, and plastrons varying from green-gray to orange yellow, some plain and others clouded. Of 8 females about 6 inches long, 2 were very light colored, the scales being marked with concentric lines of greenish gray or brown on a darker background; 2 were very dark brown, the others were intermediate; the plastron was yellowish gray-green, almost uniform in the light colored individuals, but clouded with black in the darker colored specimens. Of the males 20 had the scales of the carapace broadly margined with greenish gray, around a center of black or light brown; the lips and the top of the head were white or whitish; the plastrons were as variable as in the females described above, but the dusky markings had the form of small specks rather than indefinite cloudings. Eighteen males varied from uniform black to specimens in which the scales had a large black center and a margin of dark greenish-gray; the top of the head was black and in all but one case the lips were black; in 11 males the color was like those just described, except that the upper lip was white; in 2 males the color was dark, like those just described, but both the top of the head and the upper lip were white.

This form, although variable, can readily be recognized by its large head, smooth carapace, and low dorsal ridge. From North Carolina northward it begins to intergrade with the northern form, *M. centrata concentrica*, and is displaced altogether before the mouth of Chesapeake Bay is reached. The absence of concentric markings, usually mentioned as characteristic of the species, is apparently the common condition in typical *M. centrata*, although now and then an individual is found which shows them quite as plainly as the northern form. The usual coloration seems to be dark brownish or greenish black with a border of lighter green gray around each scale of the carapace. It is not exceptional to find individuals of this species with the transverse diameters of the shell before and behind the bridge nearly equal and the sides straight, the outline of the carapace thus a long oval.

Dealers in terrapin regard *Malaclemmys centrata* with little favor, and it commands a much lower price in the markets than the northern form. The reasons for this unpopularity are variously stated to be toughness and coarseness of the flesh, large size of the bones, lack of flavor, uninviting appearance, and it would seem that all the disagreeable qualities are found combined in the terrapin from South Carolina and Georgia; those from North Carolina are more esteemed, probably owing to the fact that among them are to be found numerous individuals which can be made to pass muster as genuine "Chesapeakes".

By Agassiz (1857, p. 438), and by Boulenger (1889, p. 89), *Emys macrocephalus* of Gray (1844, p. 26), is regarded as a synonym of *M. centrata*. Agassiz states that the species was based on a large-headed specimen of the diamond-back terrapin. An examination of Gray's description shows *E. macrocephalus* to be indeterminable, as it does not apply to any one turtle more than to another, and even the locality is doubtful.

**Malaclemmys centrata concentrica** (Shaw). The Chesapeake Terrapin. Pls. I, IV, V, and X (fig. 2).

1792 *Testudo terrapin* Schoepff, Hist. Testud., p. 64, pl. XV (name preoccupied).
1802 *Testudo concentrica* Shaw, General Zool., III, p. 43.
1825 *Emys centrata* Say, Jour. Acad. Nat. Sci. Phila., IV, p. 205 (part), &c. Numerous other authors as cited under *M. centrata*.

*Type locality.*—Both Schoepff and Shaw obtained their specimens from the markets of Philadelphia, and we may therefore fix the type locality somewhere in that region, probably Delaware Bay, as in that early day practically all the sea food handled in Philadelphia came from those waters.

*Distribution.*—The littoral region of the eastern United States from Buzzards Bay, Massachusetts, to Virginia or North Carolina; Long Island Sound, Delaware and Chesapeake bays, &c.

*Characters.*—The carapace has in general the form of that of *M. centrata*, but is broader posteriorly and the marginal plates behind the bridge are seldom revolute; the plastron, also, is less convergent posteriorly; the plates of the carapace bear conspicuous concentric ridges, but those of the plastron are smoother, nearly always, however, except in some old individuals, showing at least traces of the lines of growth; the head is small, narrow, and neatly formed, the top of it flat, giving the nose a sharper appearance than is to be seen in the other form of this species.

The color varies from uniform black to light brown, the latter always marked with darker concentric lines on each plate of the carapace and more or less blotched with darker on the plastron; the skin of the head, legs, and tail varies from nearly pure black to a very light green-gray, the latter more or less marked with specks and short, crooked lines of black; the lips and top of the head are usually dusky, but individuals may be found with either or both white.

The males resemble the females in the shape of the carapace, except that they are a little sharper posteriorly and the marginal plates are frequently a little revolute; the nose is much sharper than in the females.

It seems very probable that some of the types of coloration indicate local variation, but the species has been so thoroughly mixed by the shipping of large consignments from one place to another that it is doubtful whether anything of this kind could be proved. All the specimens from Connecticut and other northern localities, so far as I have seen, are very light in color, with conspicuous concentric markings, but very smooth shells; Potomac River specimens are similar, but have rougher plates; those from the ocean and inclosed bays of the Atlantic coast of the Maryland-Virginia peninsula are, in more than 75 per cent of the specimens, very dark and without markings of any kind. The terrapin from Delaware Bay are more like those of more northern localities, but usually present very little contrast in the color markings on the plates of the carapace.

Many varieties are recognized by the dealers in terrapin—"Chesapeakes," "Delaware Bays," "Long Island terrapin," "Connecticuts," &c.—but in most cases the determinations are nothing more than guesswork.

**Malaclemmys macrospilota**, sp. nov. The Florida Terrapin. Pls. VI, VII, and XI (fig. 1).

*Type.*—U. S. National Museum No. 33917, an adult female from Charlotte Harbor, Florida, secured at the Washington market, December, 1902, by W. P. Hay.

*Distribution.*—Salt marshes of the western coast of Florida, the limits of the range as far as known being from Charlotte Harbor northward to Sand Key.

*Characters.*—The carapace does not differ greatly in outline from that of *M. centrata concentrica*, but is nearly always a little less full along the sides between the shoulders and the hips, the sides in most cases being nearly straight: marginal scales behind the bridge revolute; carinæ of the vertebral plates always well developed and, except in very old individuals, often more or less expanded at their tips into roundish knob-like excrescences. Notch in front of shell, above the neck, deeper than in the forms previously described. Plastron usually rounded in front, its sides behind the bridge more nearly parallel and the notch between femoral and anal plates deeper than in *M. centrata*. Epidermal plates of both carapace and plastron strongly marked with concentric ridges. Head large and blunt and, owing to greater development of the masseter muscles, apparently swollen back of the jaws; horny covering of the lips strong; eyes protuberant, more so than in *M. centrata*; top of head flat. Legs and feet perhaps a trifle smaller proportionally than in *M. centrata*.

The coloration in this species is very characteristic and will serve to distinguish it at a glance. The ground color of the carapace is a deep blue-black, but near the middle of each plate and covering about two-fifths of its area is a conspicuous orange-yellow spot; the marginal plates are largely orange yellow both above and below and as these plates are revolute, a chain of color encircles the body; the plastron is largely yellow or orange yellow, this color having nearly displaced the dusky brown ground color; head and neck a peculiar whitish flesh color, the head almost unmarked but the neck with numerous small black spots; lips and top of the head white; legs and feet light grayish green with many small specks and spots of dark brown or black; tail grayish and usually unmarked.

The males are essentially like the females, though much smaller, of course, and with longer tails, but the knobs on the carinæ of the vertebral plates seem to be more persistent.

In the specimens of *M. macrospilota* examined by me, about 100 in number, I have observed little variation. Two specimens were almost entirely black, but a close examination of these showed traces of the characteristic orange blotches. In a few individuals the lips and the top of the head were dusky. When handled, this terrapin shows more readiness to bite than any of the others, and its strong jaws enable it to inflict a painful wound. In one case a piece was cut cleanly out of the palm of an incautious investigator.

It is quite surprising that this beautiful species has escaped the notice of naturalists for so many years, but perhaps the growing scarcity of diamond-back terrapin in northern waters has only recently led to the appearance of this animal in our markets. My first specimens were selected from a barrelful which had been sent from Charlotte Harbor, Florida, to a dealer in Washington. In the summer of 1903 I noticed a considerable number of both males and females in one of the pounds at Crisfield, where they had been received from Sand Key, Florida.

In the markets the "Florida terrapin" does not meet with a ready sale. Its peculiar coloration proclaims it at once as different from the Chesapeake article, and by those who have eaten it, its flesh is said to be somewhat gelatinous and entirely lacking in the qualities which have made the northern species famous.

### **Malaclemmys pileata** (Maximilian zu Wied). The Louisiana Terrapin. Pl. XI, fig. 2.

1865. *Emys pileata* Maximilian, Prinz zu Wied, Verzeichniss der Reptilien welche auf einer Reise in Nördlichen America beobachtet werden, pp. 16, 17; pl. I, figs. 2, 3.

*Type.*—No. 916, American Museum of Natural History (?) the carapace and plastron of an adult male or immature female from New Orleans, Louisiana, collected by Maximilian.

*Distribution.*—So far as is known, the range of this terrapin is along the Gulf coast from the region about the mouth of the Mississippi River eastward as far as Mobile Bay, and possibly well along the coast of Florida.

*Characters.*—This species is very similar to *M. macrospilota* in form and sculpture of carapace, size and shape of head, and proportion of parts, but it differs in coloration. The carapace is entirely black or very dark brown, except for the clear orange or dark yellow of the upturned marginal plates; the plastron is yellow, more or less inclined to dusky or olive, and sometimes with cloudings of brown or dusky. The ground color of the head and neck is a gray or green gray, very clear and light on the sides and lower part of the head, but gradually shading into dark olive brown or dusky on the neck, and everywhere thickly strewn with black or dark brown spots and specks; a large rhomboidal blackish patch on top of the head covers the entire area from nose to occiput, and touches the eyelid on each side; the horny covering of the upper lip is very broad and usually white, but often is strongly marked with dusky; between the upper lip and the black rhomboidal patch on top of the head and extending from nose to front of eye there is usually a streak of olive. The legs, tail, and soft skin of the body are nearly black, owing to the great quantity of black spots which practically cover the surface.

The male is similar to the female, but the crests of the vertebral plates are nearly always knob-like, and the size is, of course, much smaller than the adult female. The black marking on the upper lip seems to be constantly present in the male, and has been compared by Maximilian to a moustache. The plastron is nearly always quite strongly clouded with brownish black.

Maximilian's specimens were received from New Orleans while he was at New Harmony, Indiana. Since then no specimens have been obtained until two years ago, when Dr. H. M. Smith, of the Bureau of Fisheries, received two or three from the same locality. These fit Maximilian's description in every way and place the species on a firm basis. Of the nine specimens mentioned by Maximilian, six seem to have disappeared; the three others are in the collection ot the American Museum of Natural History (Nos. 799, 800, 916). No. 916 is labeled in Maximilian's handwriting, "*Emys pileata* mihi, *Emys concentrica* var. Dum. et Bibr." The original number of this specimen appears to have been 65; the other two were numbered 66 and 67. The locality as given on the labels is "Texas, New Orleans." The specimens are small, and probably represent males from 5 to 7 years old.

It has been possible to examine only three or four specimens of this turtle from the type locality, but I have seen large numbers of females from Biloxi, Mississippi, and Mobile, Alabama. They appear in the markets under the name of Biloxi terrapin or Gulf terrapin, and, next to the northern form of *M. centrata*, command the highest prices. They are said to be rather tough, however, and according to some opinions are not so delicately flavored as the "genuine Chesapeakes." In one or two instances among the Mobile specimens there was the faintest possible indication of a large whitish blotch on each plate of the carapace, and subsequent investigation may show that the present species and *M. macrospilota* intergrade at some point on the Florida coast. At present, however, the indications of this are so slight that the two must be regarded as distinct.

**Malaclemmys littoralis,** sp. nov. Pls. VIII, IX, and XII (figs. 2 and 3).

*Type.*—U. S. Nat. Mus. No. 33913, an adult female from Rockport, Texas, secured at Crisfield, Md., in August, 1904, by W. P. Hay.

*Distribution.*—Salt marshes and channels along the coast of Texas and outlying islands.

*Characters.* Carapace oval in outline, but of nearly equal width at shoulders and hips, the sides convex, straight, or even slightly concave; notch above the neck usually deeper than in the species previously described; carapace much more vaulted, greatest height usually farther back than in the other species, being at top of third vertebral plate; marginal plates in front of the bridge blunt at the edges, behind the bridge sharper and rather strongly revolute; margin of carapace rounded just above the bridge, so that the sharp longitudinal ridge, so prominent in all the other species, is almost wanting; bridge high; plastron narrower proportionally than in the other species; posterior lobe with more convergent sides. Plates covering the shell thin with old age, often becoming so worn away as to expose the bone beneath them; plates on the plastron usually quite smooth. on the carapace sometimes smooth, but usually concentrically ridged or roughly pitted.

Head large, the nose blunt. In the male the carapace is flatter than in the female marginal plates from near front of the shell backwards strongly revolute; plates of the carapace much pitted.

The coloration is variable. Of the 250 specimens examined the few males were all dark brown; there were a few females which were almost black, with dark heads, necks, and legs; others were so light a greenish gray as to appear almost white; the majority, however, were brown, varying from rather light yellowish brown to dusky. The upturned marginal plates in the darker colored individuals were orange, but in light-colored specimens were light greenish gray or nearly white; the plastron was usually yellowish, but if the carapace was very light colored, the plastron was nearly white with a faint greenish tint; the markings on the plates of the carapace were always indistinct, but occasionally there was a faint indication of one or two concentric bands near the centre; usually, however, the plates were only slightly and irregularly clouded, or unmarked. The top of the head was usually dusky, but sometimes white, and the upper lip was white in every individual. The soft skin was everywhere a pronounced green-gray, but thickly marked and more or less obscured by small, nearly circular, black or brown spots.

All the terrapin of this species that I have seen alive came from Rockport, Texas, but they are said to occur southward as far as Brownsville, at least, and northward as far as Galveston. In the American Museum of Natural History there are four specimens of this turtle, Nos. 801, 802, 804, and 805, which were probably collected by Maximilian; no locality is given for them other than Texas. It is quite possible that the range of this species and that of *M. pileata* merge somewhere between Galveston and New Orleans, and it may be that the two will be shown to be more closely akin than is indicated by the classification adopted here. The very dark brown individuals of *M. littoralis* are very similar in general appearance to the Mobile Bay specimens of *M. pileata*, but may usually be distinguished by the higher and heavier body and the white upper lip.

A very interesting malformation, consisting in the longitudinal division of one or more of the vertebral plates, was observed in many individuals of this species, a condition so common that it was really difficult to pick out a full-grown specimen which did not show it in some degree. As to the possession of the inguinal plate, these terrapin were variable; of 50 specimens examined for this character, 26 had it and in 24 it was wanting.

The young of *M. littoralis* are very remarkable, and in the absence of any other distinctive characters would serve to separate the species from *M. centrata*. I have secured a good series of the young from eggs laid in one of the terrapin pounds near Crisfield, Maryland. They are much larger than the young of *M. centrata*, having probably twice the bulk, and seem much more vigorous and lively. The first vertebral plate is raised on the middle line to form a broad, low carina; on the second plate the elevation is greater, and stands out as a smooth boss on the otherwise finely wrinkled plate; the elevation on the third plate has the form of a hemispherical button with a well-marked constriction around the posterior half of the base, so that it stands up prominently above the plate posteriorly but anteriorly slopes into it; on the fourth plate the elevation rises into a knob-like protuberance from a base which is constricted all around; the tubercle of the third plate is usually the broadest, but the one on the fourth plate is the highest and most conspicuous of the three; all are smooth and polished, while the plate upon which they rest is finely wrinkled. The fifth vertebral plate is flat or with only a trace of an elevation. The color of these young specimens is brownish yellow or horn color, and the margins of all the plates of the carapace are thickened and darker than the remainder of the plate. The centres of the costal plates usually bear a small dark dot, around which there is sometimes a narrow dark ring.

Attention has already been called to the knob-like tubercles observable on many specimens of *M. macrospilota* and *M. pileata*, and these unquestionably have their origin in structures such as those just described in *M. littoralis*. In the latter species they seem to disappear with age, but in *macrospilota* and *pileata* they persist, in the males at least, for many years, increasing in size very little, if at all, but very conspicuous when present. In the hundreds of adult and young terrapin from the Atlantic coast which have come under my observation, nothing approaching this character has been found, and it will therefore serve to divide the genus into two distinct groups.

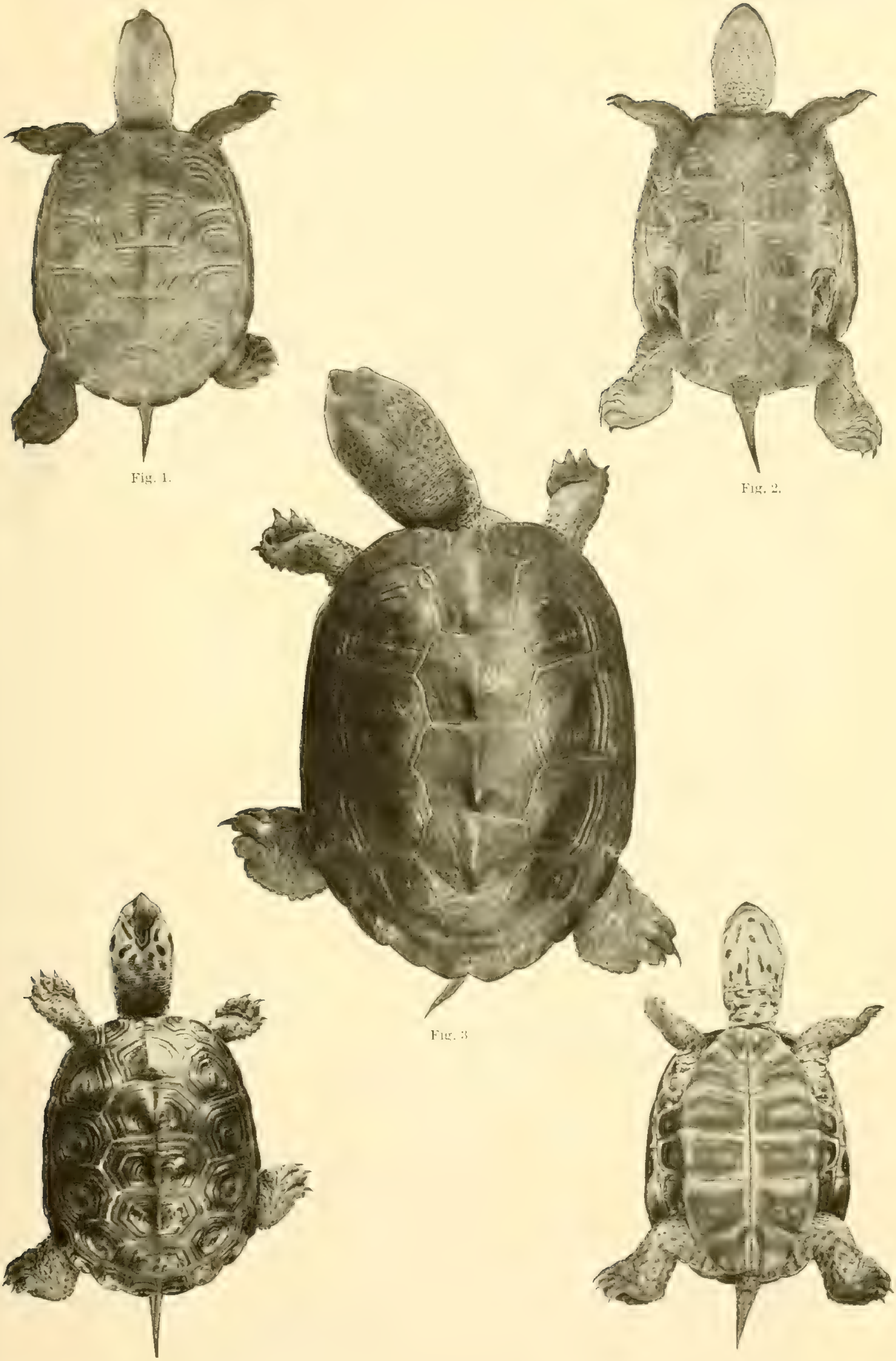


Fig. 1.

Fig. 2.

Fig. 3

Fig. 4.

Fig. 5.

MALACLEMMYS CENTRATA, FEMALE. SPECIMENS TAKEN NEAR BEAUFORT, N. C.

Figs. 1 and 2. An individual 4 inches long. Fig. 3. A nearly full-grown individual 6½ inches long. Figs. 4 and 5. An individual 3⅞ inches long.

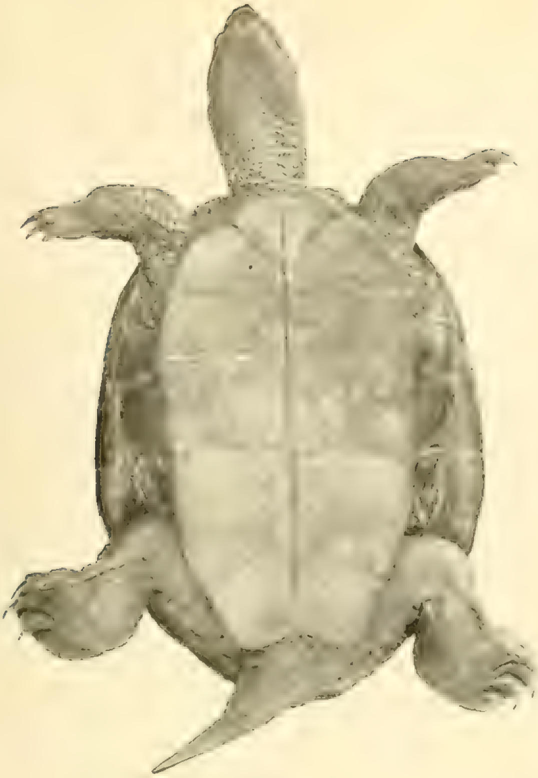


Fig. 1.

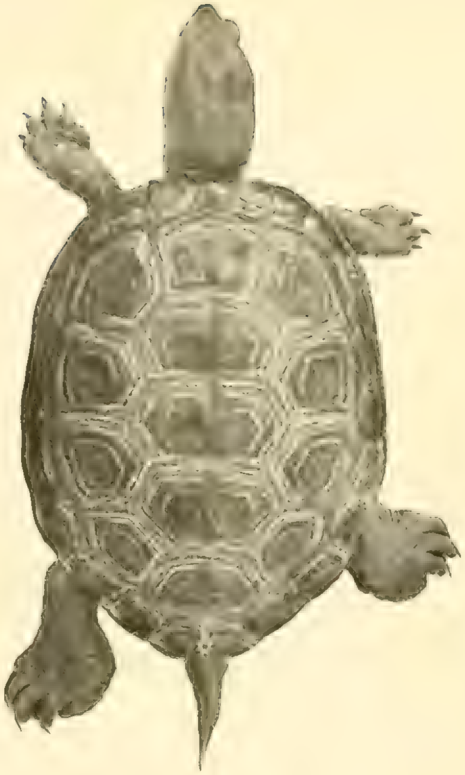


Fig. 2.

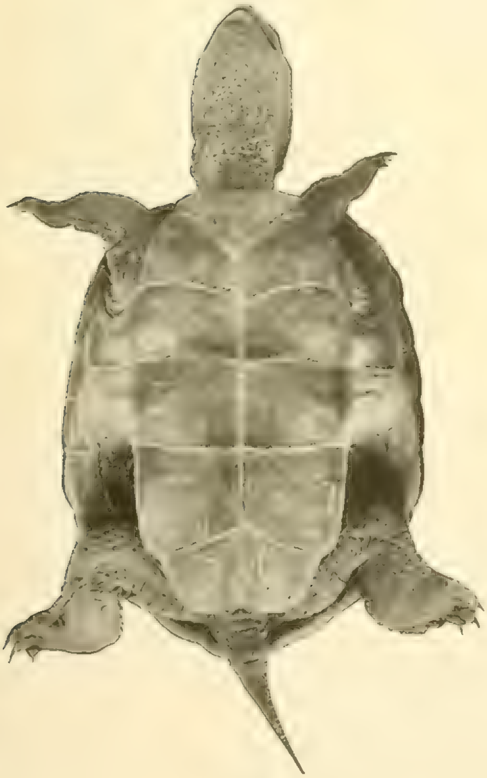


Fig. 3.

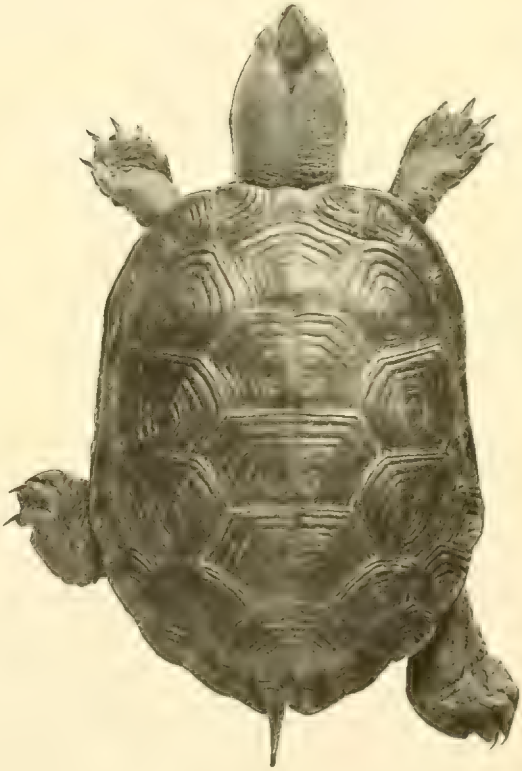


Fig. 4.

MALACLEMMYS CENTRATA. SPECIMENS FROM BEAUFORT, N. C.

Figs. 1 and 2. An adult male 4 inches long. Fig. 3. A 3-inch female. Fig. 4. A 4½-inch female.

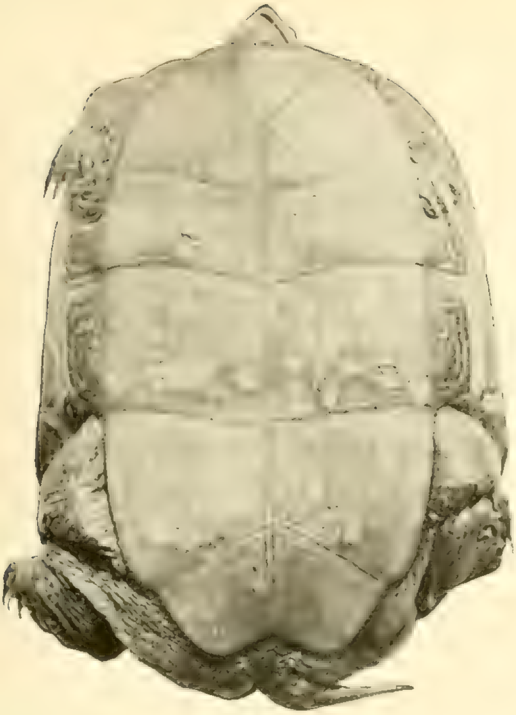


Fig. 1.

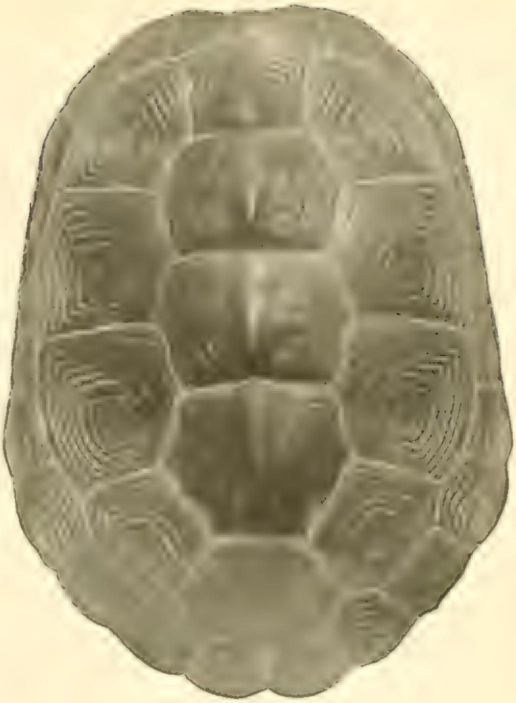


Fig. 2.

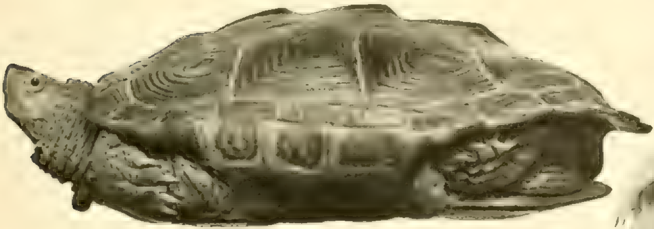


Fig. 3.

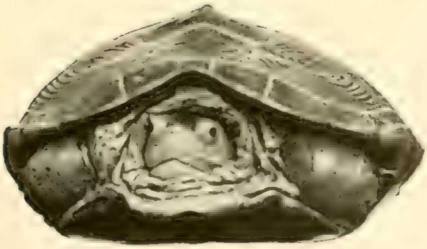


Fig. 4.

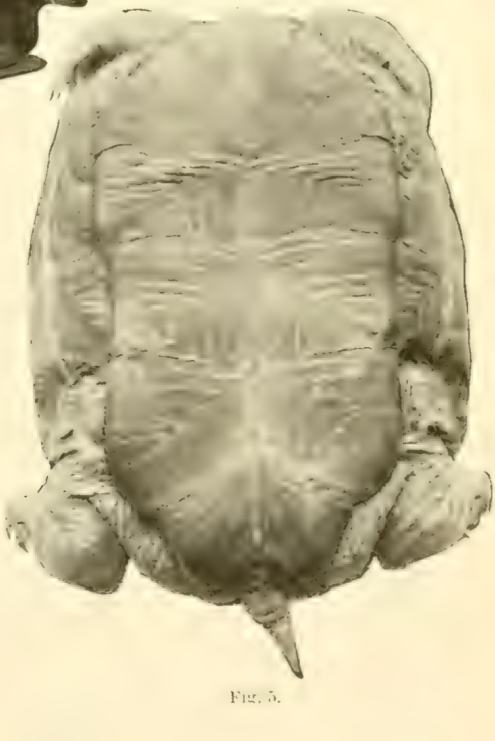


Fig. 5.

MALACLEMMYS CENTRATA CONCENTRICA, FEMALE.

Figs. 1-4. An individual 7¼ inches long, from Chesapeake Bay. Fig. 5. An individual 5⅛ inches long, from the same locality.

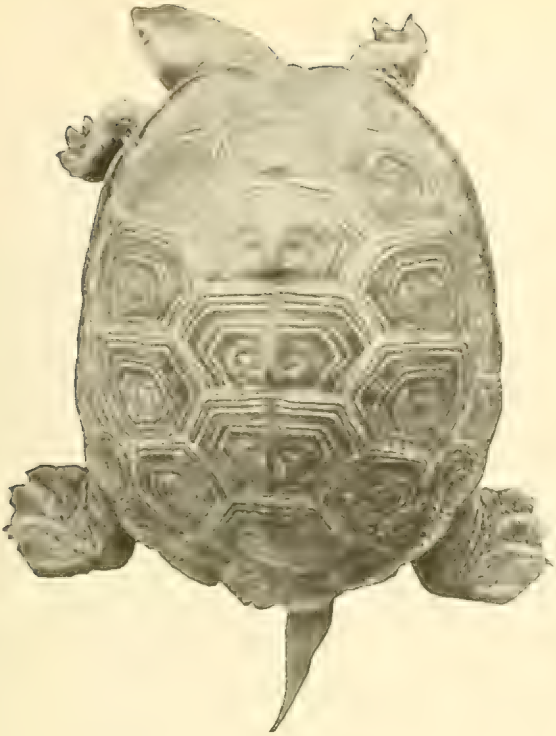


Fig. 1.

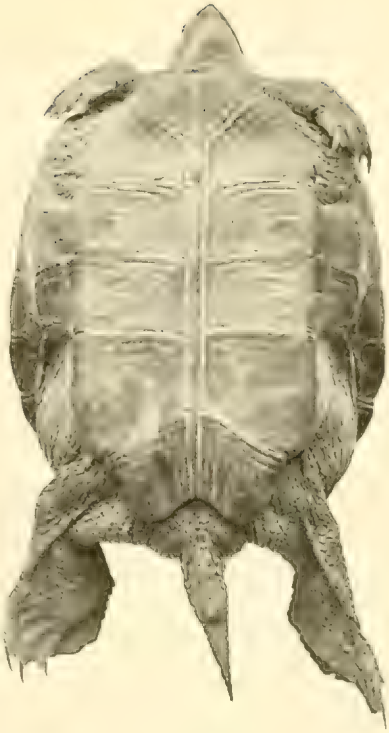


Fig. 2.

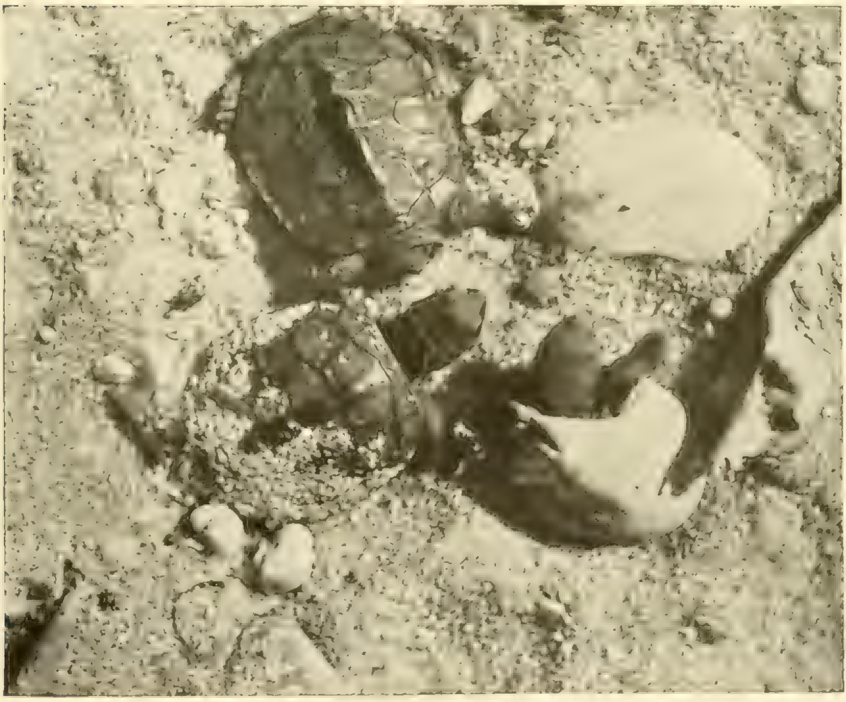


Fig. 3.

MALACLEMMYS CENTRATA CONCENTRICA.

Figs. 1 and 2. An adult male, from Chesapeake Bay (about two-thirds natural size). Fig. 3. Young, of same species, leaving the nest (about natural size).

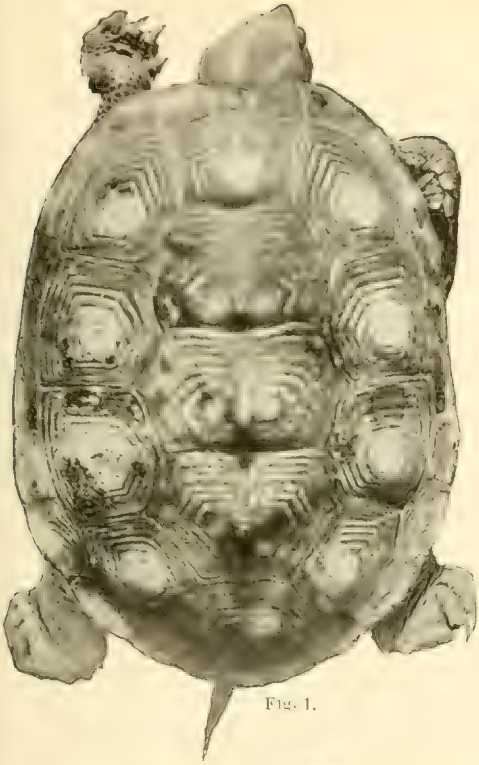


Fig. 1.

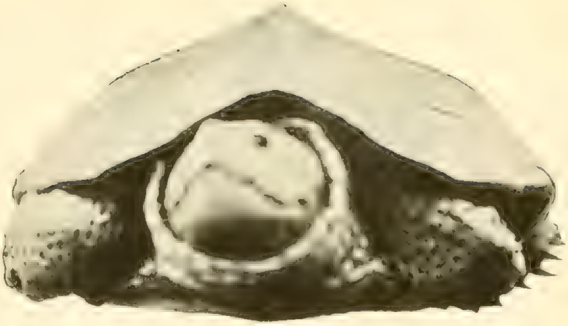


Fig. 2

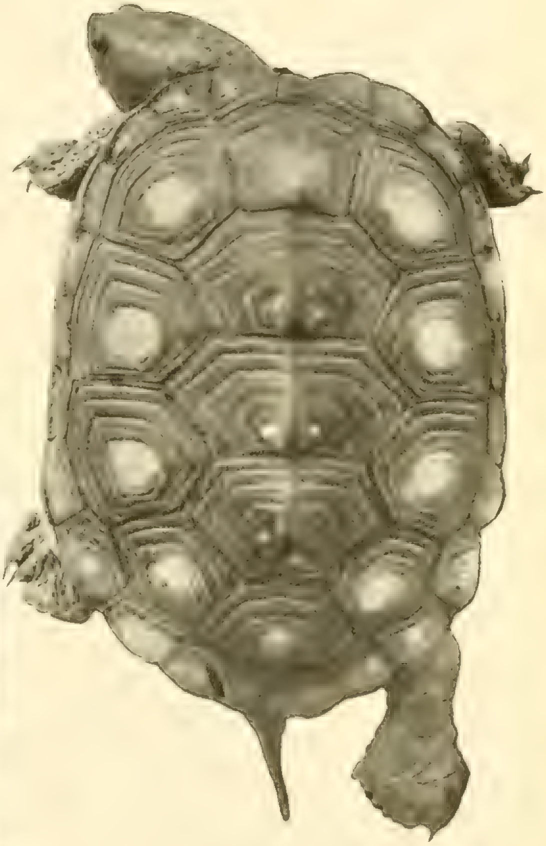


Fig. 4

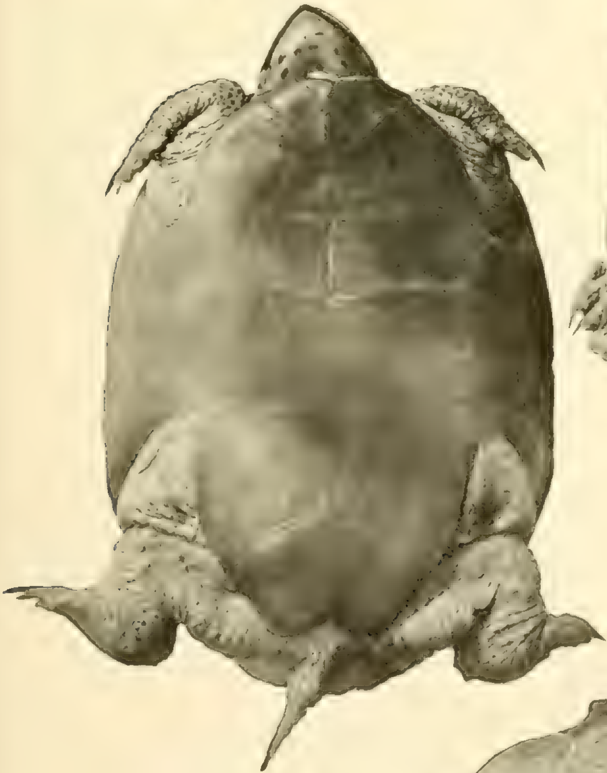


Fig. 3.

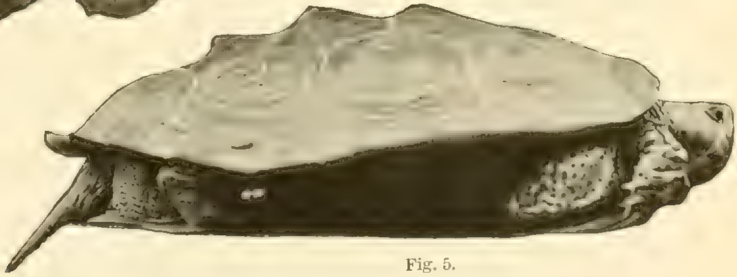


Fig. 5.

MALACLEMMYS MACROSPILOTA, FEMALE.

Fig. 1. An individual about 6 inches long, from Sand Key, Florida. Figs. 2-5. An individual 6½ inches long, from the same locality.

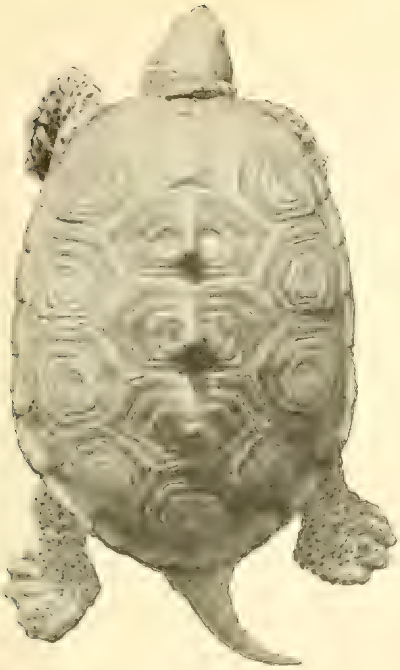


Fig. 1.

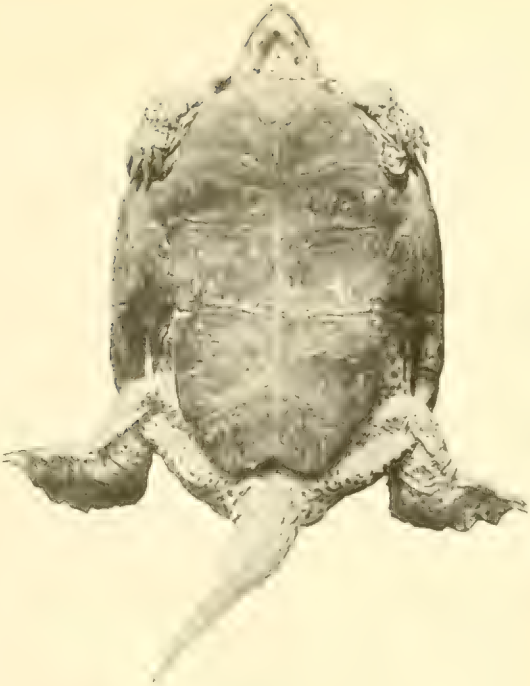


Fig. 2.

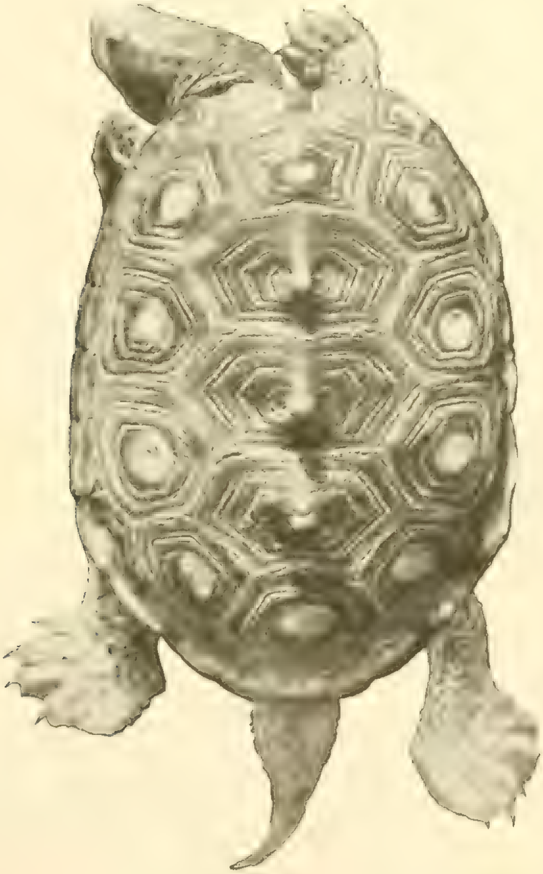


Fig. 3.

MALACLEMMYS MACROSPILOTA, MALE.

Figs. 1 and 2. An adult from Sand Key, Florida (about one-half natural size). Fig. 3. Another individual from the same locality, showing tubercles on the vertebral plates (about two-thirds natural size).

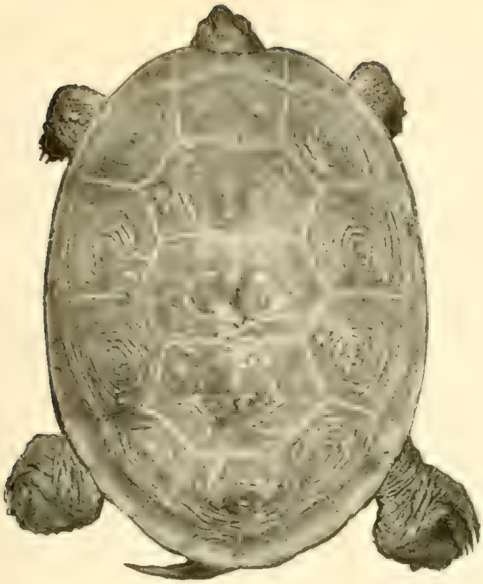


Fig. 1.

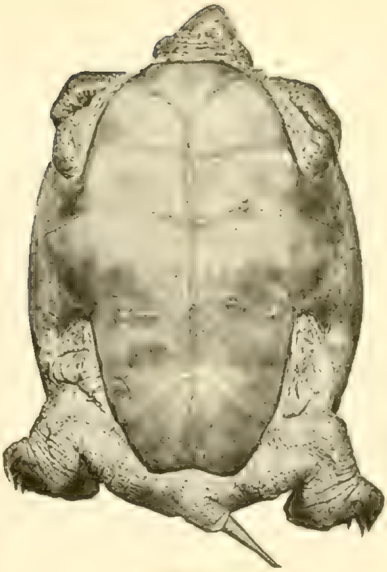


Fig. 2.

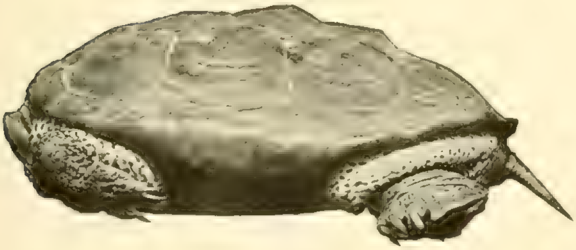


Fig. 3.

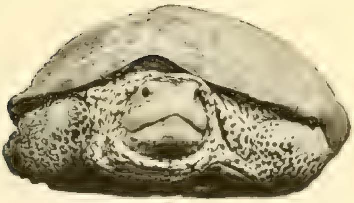


Fig. 4.

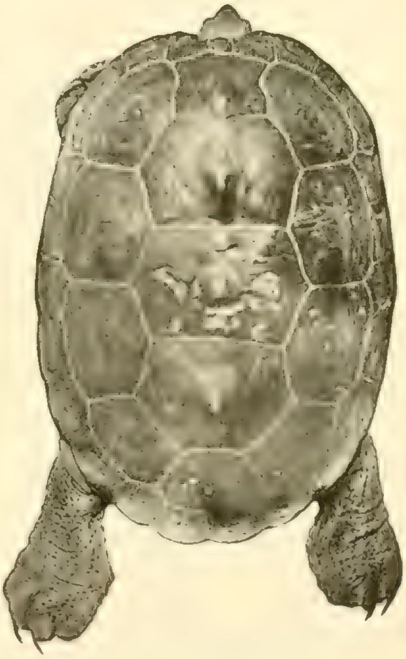


Fig. 5.

MALACLEMMYS LITTORALIS, FEMALE.

Figs. 1–4. An individual 7 inches long, from Rockport, Tex. Fig. 5. A slightly smaller individual.

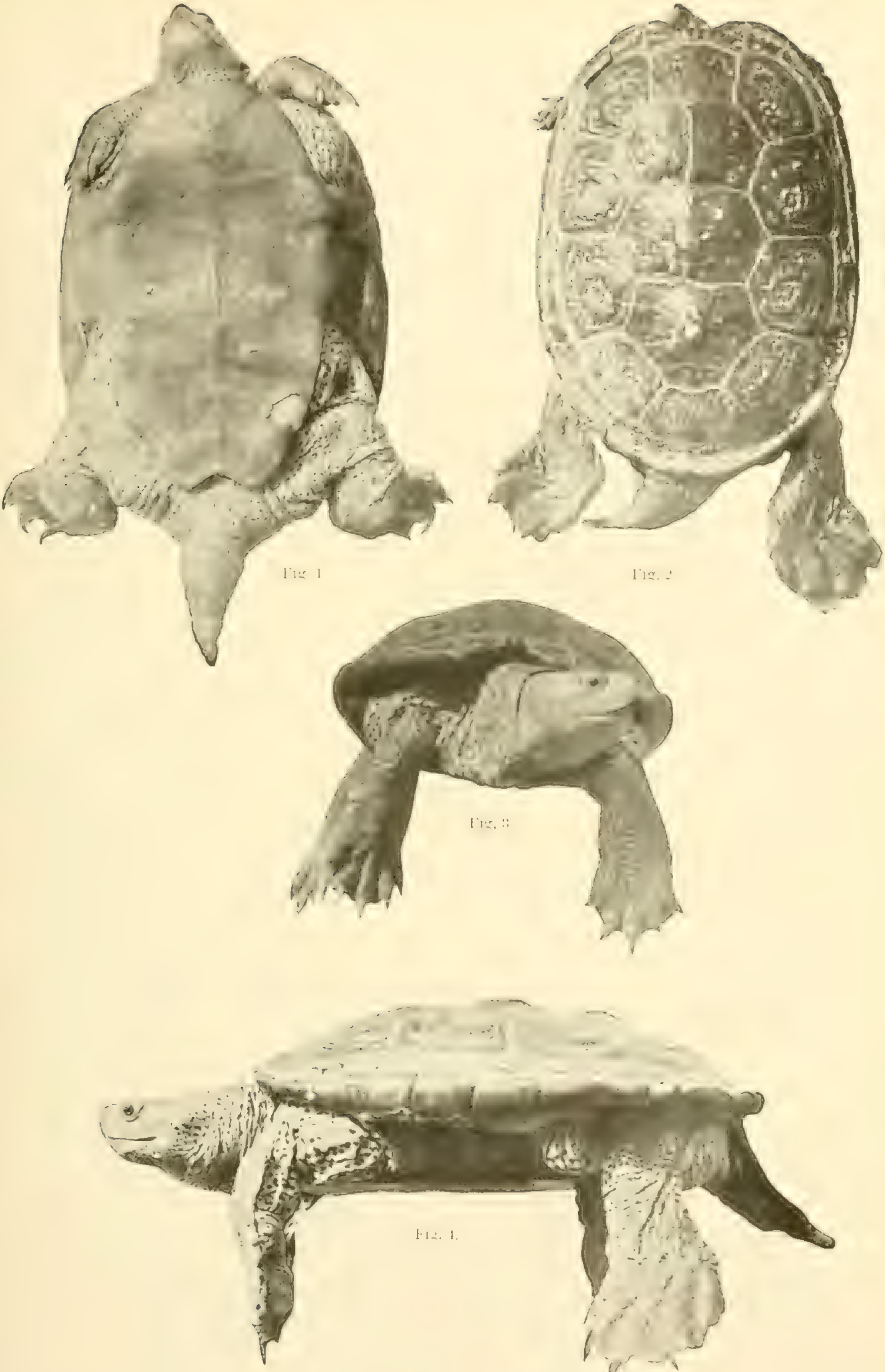


Fig. 1

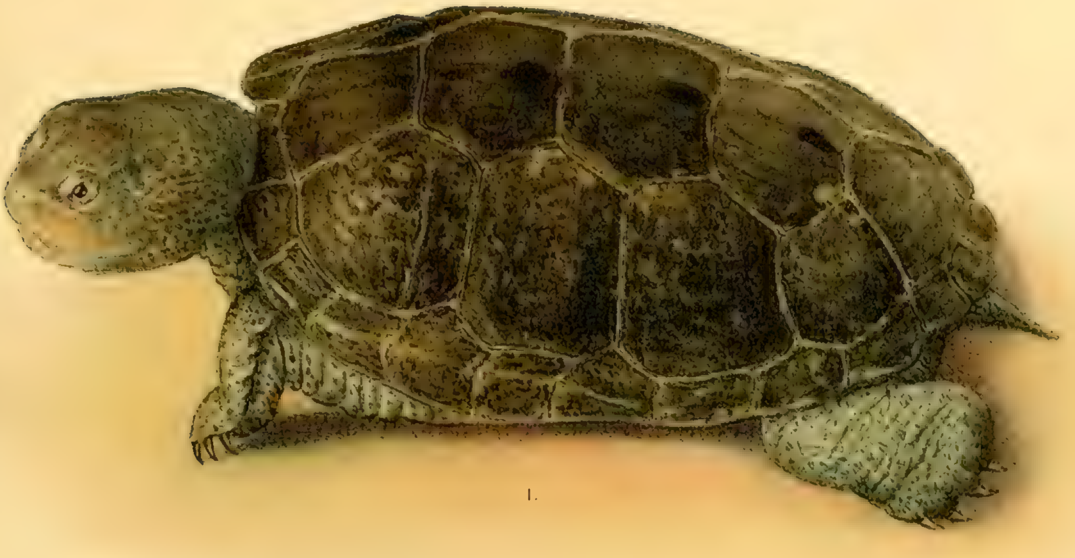
Fig. 2

Fig. 3

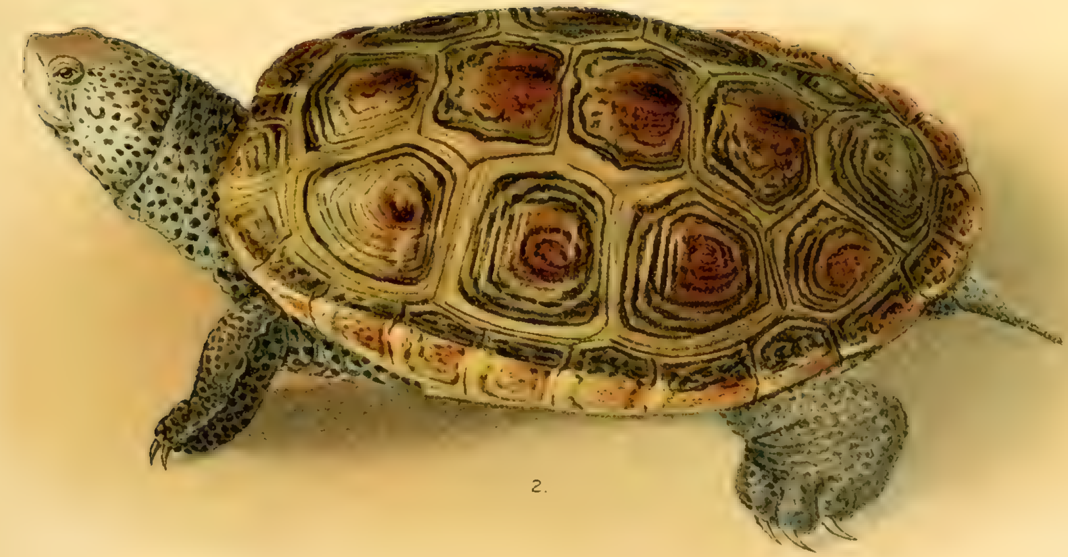
Fig. 4.

MALACLEMMYS LITTORALIS.

The figures represent the same individual, an adult male 5 inches long, from Rockport, Tex. The tip of the tail has been injured.



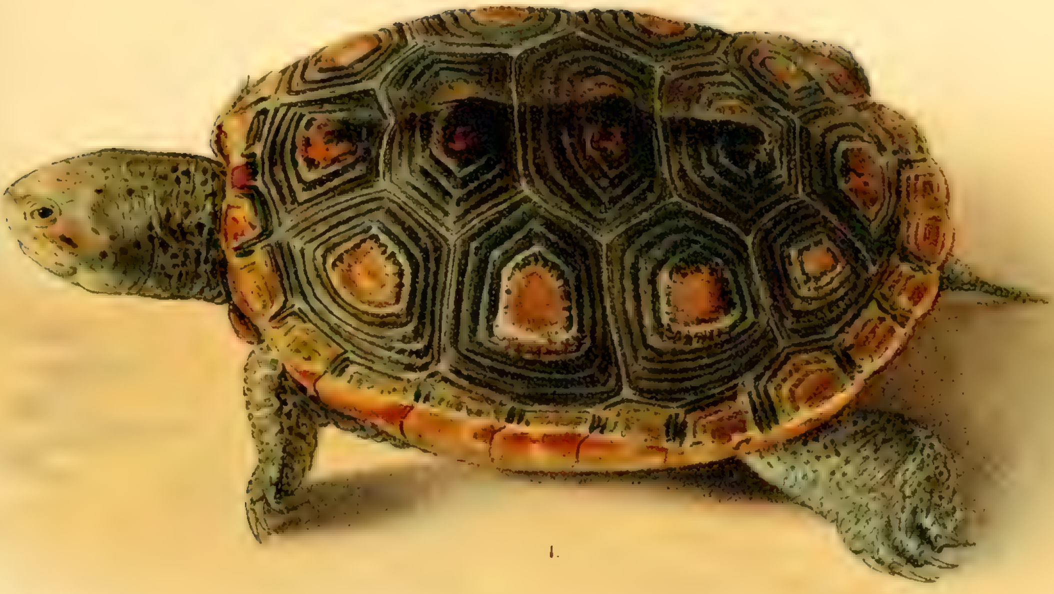
1.



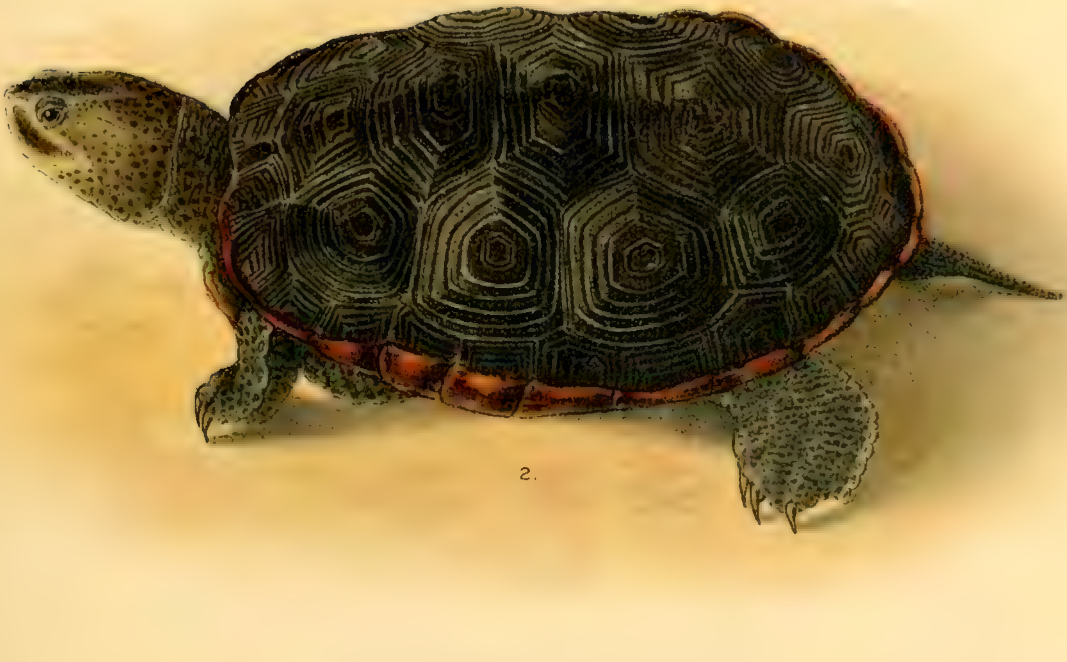
2.

1. MALACLEMMYS CENTRATA
2. MALACLEMMYS CENTRATA CONCENTRICA

JULIUS BIEN & CO. N.Y.



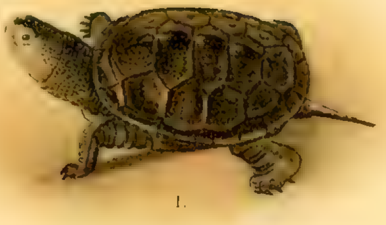
1.



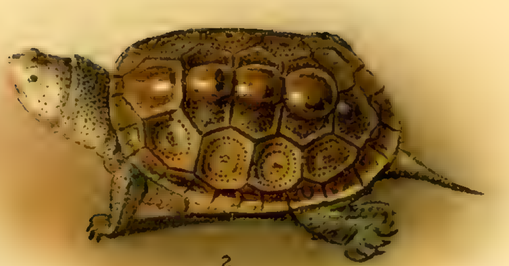
2.

1. Malaclemmys macrospilota
2. Malaclemmys pileata

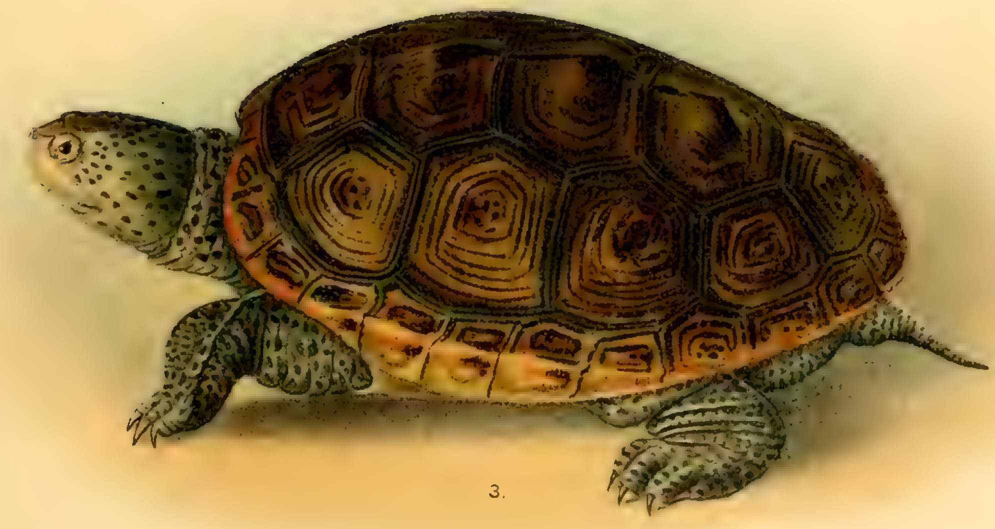
JULIUS BIEN & CO NY



1.



2.



3.

1. MALACLEMMYS CENTRATA (YOUNG).
2. MALACLEMMYS LITTORALIS (YOUNG).
3. MALACLEMMYS LITTORALIS (ADULT).

JULIUS BIEN & CO N.Y.

CONTRIBUTIONS FROM THE BIOLOGICAL LABORATORY OF THE BUREAU OF FISHERIES
AT WOODS HOLE, MASS.

# THE MEDUSÆ OF THE WOODS HOLE REGION.

By CHARLES W. HARGITT,
*Professor of Zoology, Syracuse University.*

CONTRIBUTIONS FROM THE BIOLOGICAL LABORATORY OF THE BUREAU OF FISHERIES
AT WOODS HOLE, MASSACHUSETTS.

# THE MEDUSÆ OF THE WOODS HOLE REGION.

By CHARLES W. HARGITT,
*Professor of Zoology, Syracuse University.*

## INTRODUCTION.

The present report forms one of a series projected by the director of the biological laboratory of the United States Bureau of Fisheries, the primary object being to afford such a biological survey of the region as will bring within easy reach of students and working naturalists a synopsis of the character and distribution of its fauna.

The work which forms the basis of this paper was carried on during the summers of 1901 and 1902, including also a brief collecting reconnaissance during the early spring of the latter year, thus enabling me to complete a record of observations upon the medusoid fauna during every month of the year, with daily records during most of the time. For parts of these records during late fall and winter I am chiefly indebted to Mr. Vinal N. Edwards, which it is a pleasure hereby to acknowledge. It is also a pleasure to acknowledge the cordial cooperation of the Commissioner, Hon. George M. Bowers, and of Dr. H. M. Smith, director of the laboratory in 1901 and 1902.

Most of the drawings have been made directly from life by the writer or under his personal direction. A few of those occurring in the text have been copied from various sources, due credit for these having been given in every case, so far as known.

Since the publication of "North American Acalephæ" by Alexander Agassiz in 1865 no connected and systematic account of the medusoid fauna of the north-eastern Atlantic coast has been undertaken. Various reports dealing only incidentally with this phase of the subject have been made from time to time by Prof. A. E. Verrill, notable among these being that known as "The Invertebrate Fauna of Vineyard Sound," in the Report of the United States Fish Commission for 1871; and a number of papers by J. Walter Fewkes have appeared in issues of the Bulletin of the Museum of Comparative Zoology, describing new species and incidentally giving some account of their morphology. More recent contributions are several articles by Mr. A. G. Mayer, in conjunction with Mr. A. Agassiz, dealing with various aspects of the subject, though not limited especially to this region—indeed, only touching it in a very general way.

While by reason of the peculiar interrelations of hydroids and medusæ the present paper may here and there touch to a limited extent a phase of the subject included in Nutting's "Hydroids of the Woods Hole region," it will not materially duplicate that work, but rather supplement and extend it, the two parts forming a fairly complete summary of the entire phylum, the Anthozoa alone excepted. The present paper will also include something in the nature of a synopsis of the development of representative forms, together with data as to habitat, seasonal variations, etc. The region covered will be about that already outlined by Nutting, namely within the limits of a single day's cruise from the Fisheries Station; for example, Cape Cod and Nantucket on the east, the Gulf Stream on the south, and Narragansett Bay or Long Island Sound on the west.

The order of presentation will follow substantially that adopted by the present writer in the "Synopsis of the Hydromedusæ," recently published in the American Naturalist, which follows in general order and nomenclature Haeckel's "System der Medusen," though without adherence to that or any special authority, except as noted in the body of the paper. While deploring the more or less chaotic condition of existing systems of taxonomy in relation to coelenterates, it has not seemed expedient to propose any radical changes at present, even if data were available for such an undertaking. A prerequisite thereto, and one open to students of the group everywhere, is the critical study of ontogeny. Unfortunately, this has not only been neglected in too many cases, but the tendency to devote attention to a single phase of the subject, for example, the *hydroid*, or on the other hand the *medusa*, has, perhaps indirectly, cultivated the neglect. It is greatly to be desired that in the future less emphasis be placed upon elaborate monographs of "Gymnoblastic Hydroids" or "System der Medusen," valuable as these have been, and more upon monographs of Hydromedusæ, or, in other words, monographic details of the ontogeny of species, constitution of genera, families, and orders, including also critical data as to the varietal effects of environment, nutrition, etc. Such monographs would afford final data from which a consistent and scientific taxonomy might be established.

Except in so far as necessary in order to obviate ambiguity, little effort has been devoted in the present report to details of synonymy, or to the unraveling of conflicting claims of priority, etc.

## GENERAL ACCOUNT.

Under the general title of "Medusæ" are included animals of a remarkable range of size, habits, distribution, and life history. In size they vary from less than a millimeter in diameter in the adult condition, as in many of the Hydromedusæ, up to enormous specimens of Scyphomedusæ, more than 2 meters in diameter and with tentacles more than 30 meters in length.

One of the interesting anomalies associated with some of these animals is that notwithstanding their large size, no less than 99 per cent of the entire mass is composed of water, so that a specimen exposed upon a clean surface to the desiccating influence of sun and air would, after a few hours, leave hardly sufficient organic matter to identify the place. Such being the case it might not be a wholly unwarranted paradox to define a medusa as organized and animated sea water.

In habit most medusæ are marine, though a few are known to occur in fresh waters of inland lakes. Most are free swimming at some time during their life history, yet not a few among both Hydromedusæ and Scyphomedusæ are permanently sedentary, some as degenerate sporosacs, others as polyp-like forms such as the Lucernaridæ. In distribution they range from a littoral to a pelagic life and from the surface to abyssal depths.

Under the head of Medusæ is also usually included a group of animals of similar form and habits, though of somewhat doubtful structural affinities, namely, the ctenophores or "comb-jellies." While admitting a reasonable doubt as to their true morphological relations, the ctenophores may still be most conveniently recognized as a distinct class of medusæ and included within the present synopsis. Hence species indigenous to this region will be noted and briefly described.

Concerning the economic relations of medusæ very little is known. That they sustain intimate general relations to the varied forms of marine life can hardly be doubted. Their vast numbers, wide distribution, and more or less active life habits all support the general inference. The well-known cases of commensalism existing between medusæ and several species of fishes which follow them at times with more or less persistence, often taking refuge in the frills of the pendulous lobes of Scyphomedusæ, and resisting efforts to separate them, still further suggest the probability. Some fishes are said to feed upon the oral tentacles and margins, as well as the larger tentacles of the umbrella, which they tear off at times with great vigor. Often, however, the medusæ reverse the operation and devour the fishes. It does not seem likely that medusæ can afford any large measure of food for fishes in general, but several species of fish are known to feed upon them at times with great avidity. The horned dog-fish, *Squalus acanthias*, when first arriving at Woods Hole in the spring migration, in May, is said to feed largely on ctenophores. (H. M. Smith.) The sun-fish, *Mola mola*, and also the file-fish, *Alutera schoepfii*, have been found by Mr. Vinal Edwards to have fed entirely on ctenophores and medusæ.

As a special case of mutualism between fishes and medusæ may be mentioned that of the young of the butter-fish, *Rhombus triacanthus*, found with *Dactylometra quinquecirra*. Whether this particular case is of more than temporary nature may be doubtful. So far as I am aware it is chiefly, if not wholly, limited to the period of the young fish. Another case of similar character is that of the Portuguese man-of-war, *Physalia pelagica*, with its commensal, the Portuguese man-of-war fish, *Nomeus gronovii*. In a single excursion in 1894 the United States Fish Commission collected 21 specimens of this fish, averaging 6 inches in length, all of which were found associated with *Physalia*. A dozen specimens of *Nomeus* have been found under a single *Physalia*. (H. M. Smith.)

While the importance of medusæ as food for fishes may as yet be an open question, there can be no doubt, on the other hand, that fish, especially the fry, are an important article of food to many medusæ. Even small Hydromedusæ, such as *Gonionemus*, gorge themselves with fry frequently too large to be entirely swallowed, and large medusæ, like *Cyanea* and *Aurelia*, are often found with their stomachs filled with fish of considerable size, some of which are often in a partially digested condition. It is not rare to observe the capture of minnows by medusæ in the aquarium. In general, however, so far as my own observations go, the principal food source of the smaller medusæ is copepods, and since copepods also furnish an important part of the food of fish fry, the relations of fish and medusæ in certain cases may be due to the relation of both to a common source of food.

In this connection may be noted another feature of medusoid life, namely, susceptibility to certain parasites. When working upon the regeneration of medusæ, I found several species of Protozoa very closely associated with them and, under the limitations of the aquaria, often exceedingly troublesome, seriously interfering with the progress of the experiments. This suggested the probability of a parasitic relation. I have also found several species of Hydromedusæ infested with a minute nematode, a species of *Distomum*, which in many cases was so abundant as to permeate almost every part of the medusa. The parasitism of a small actinian, a species of *Edwardsia*, on *Mnemiopsis leidyi*, is well known, though the entire history of the case is not yet fully determined.

The irregular and apparently capricious occurrence and distribution of medusæ has long been known but little understood. That many have a seasonal period there can hardly be reasonable doubt. Such for example is true of *Hybocodon*, *Sarsia*, *Tima*, *Pennaria*, etc., among Hydromedusæ, and *Dactylometra*, *Cyanea*, and to a less extent *Aurelia*, among Scyphomedusæ. Further consideration will be given to this in connection with the subsequent descriptions.

Agassiz has called attention to the gregarious habit noted among many medusæ at certain times and places (cf. Catalogue of North American Acalephæ, pp. 42, 46), and has sought to explain the phenomenon as due to breeding conditions. This seems to me a somewhat gratuitous assumption, as facts do not confirm it so far as my observations have gone. As I have elsewhere suggested, it seems much more probable that these aggregations may be quite as easily accounted for by the influence of prevailing winds, tides, etc. At no time have I seen *Cyanea* in greater numbers than in April, when the specimens were very small, hardly more than 2 to 3 inches in diameter, and sexually immature. A change in the direction of wind or tide would disperse them again within a day's time so that only by careful search could an isolated specimen here and there be noted. This is true likewise of many Hydromedusæ, which may often occur in large numbers for a day or two and then as suddenly disappear. The occurrence of some other species, however, is less easily explained. For example, *Rhegmatodes tenuis* and *Staurophora laciniata* I have taken but twice at this station in ten years. Both of these being of littoral habitat their appearance could hardly be accounted for by a heavy wind from the direction of the open sea, as may be the case with pelagic forms like *Trachynema* or *Physalia*. When we know more definitely the details of the life history of such forms, light will undoubtedly be thrown upon this as well as many other more or less obscure phenomena concerning them.

A feature more or less similar to those just discussed is the apparently nocturnal habits of not a few medusæ. Whether the occurrence at the surface during the early evening or night can be said to constitute a definitely nocturnal habit may be an open question, but certain it is that there is here a fairly well-defined responsiveness to light and darkness. This has been experimentally demonstrated in several well-known cases—for example, *Gonionemus*, *Pennaria*, etc., where advantage has been taken of it to secure the discharge of ova at times other than those normal to the species. May there not be here also an explanation of a fact that has been often observed—namely, that cloudy or foggy days are frequently better times for collecting from the surface than bright, clear weather? If, however, such a nocturnal, or negatively heliotropic, habit exist, we must seek the seat of response in different organs. If we may allow that sensory bulbs are present in *Gonionemus* and are visual, we shall be confronted with a variation of the problem in *Pennaria*, which is wholly devoid of such organs, and without sign of ocellar bodies. It should be noted in this connection that experiments on *Pennaria* as to the effects of darkness were entirely negative in results; at the same time no medusa known to me is more apparently responsive to twilight conditions in its liberation from the hydroid, and in the prompt discharge of its sexual products immediately after. I have elsewhere pointed out that *Pennaria* shows certain aspects of degeneration, and among them the visual organ may have been involved. If such has been the case, the process must have been a gradual one, during which the visual function may have become more or less generalized and distributed over the entire nervous organization, or to generalized sensory cells similar to those of many other well-known animals, as the earthworm, for instance.

The brilliant coloration of many medusæ is too well known to naturalists to need particular emphasis, and to the general reader it will suffice to refer to the accompanying plates, from some of which a better idea may be obtained than would be given by means of verbal description. Like several of the problems already raised, that of color is noteworthy, if not indeed among the most difficult associated with medusoid morphology, in connection with which it has usually been considered. As will be seen from the following discussion, there is good reason to believe that the most hopeful outlook for its solution lies along the line of physiology rather than morphology.

As already pointed out, many medusæ are apparently devoid of visual organs, and this fact alone would seem to preclude the usual explanation of coloration as found among animals possessing eyes of any marked acuteness. Again, it has been pointed out that many medusæ are of abyssal habit, where solar light is almost if not wholly absent, and where in creatures with or without eyes color as a physical feature must necessarily be of minimum value. Many naturalists have speculated upon these phenomena, and various theories have been proposed by means of which it was sought to bring them into some sort of harmony with our ordinary conceptions of color as a factor in adaptation and natural selection. It has been suggested that the absence of solar light at great depths is measurably compensated for in the presence of phosphorescence, a property known to be possessed by not a few abyssal animals, and that this is adequate for the recognition of colors, or to render colors variously protective.

While these views are interesting and somewhat suggestive, they seem to me to fall far short of affording even an approximation toward anything like a solution of the simplest aspects of the problem involved. That phosphorescence may afford some small measure of illumination when possessed by segregated groups of deep-sea forms may be true, but not more so than in the case of surface and littoral animals of similar properties. So far as I am aware, there has been little, if any, disposition to interpret phosphorescence among the latter as serving any such function; and while this alone may not disprove for it a function very different under the very different condition of deep-sea life, the burden of proof rests upon those who make the claim. Whether available or not for animals with functional visual organs, however, it fails to touch the problem among creatures which, like many of the medusæ, are wholly devoid of such organs; but interesting as might be further discussion, the present is not the most appropriate place for the treatment of this and related problems, nor is their morphological aspect likely to afford more than mere plausibility. As suggested in a previous paragraph, it seems to me to be a physiological rather than a morphological question. This phase has been discussed by me elsewhere (cf. Science, Jan. 22, 1904), and the briefest summary is all that can be attempted here.

It was long ago pointed out by Darwin himself that color among lower forms could not have any value as a factor in natural selection; it was considered as an expression of the "chemical nature or minute structure of their tissues," and Wallace regarded color as "a normal product of organization" among such creatures. It has more recently been determined that among annelids, mollusks, and, indeed, among certain insects, coloration often results from the purely physiological processes of excretion, and I have shown that the same is probably true concerning the coloration of medusæ and other cœlenterates. Morgan and Stevens have demonstrated that among hydroids during regenerative processes pigmentary matters, which were first thought to have an important function, were in reality waste products in process of elimination. The marked changes of coloration often observed in these organisms under artificial environment have been shown to be associated with changed conditions of nutritive metabolism in some instances, while in others light has been found to be an important factor.

Similar observations and conclusions are not lacking concerning coloration among echinoderms, crustacea, and many other groups. Without seeking to discredit the value of color as a factor in adaptation among some of the highly specialized groups, I can not repress the conviction that its importance in this respect has been greatly overestimated.

## SYSTEMATIC SYNOPSIS.

The medusæ comprise three fairly well differentiated classes, known as Hydromedusæ, Scyphomedusæ, and Ctenophora, and distinguishable by the following diagnostic characters.

I. HYDROMEDUSÆ.—Definite velum, gonads usually ectodermal and developed upon the walls of the manubrium or beneath the radial canals; sensory organs in the form of ocelli or otocysts, never modified tentacles. Polyp stage usually present, but devoid of gastric filaments or ridges, and producing medusæ or sporosacs by a process of budding.

II. SCYPHOMEDUSÆ.—Devoid of true velum; gonads always entodermal, and borne within the gastric pouches; sensory organs when present are usually entodermal and are perhaps modified tentacles. Polyp stage when present possessed of distinct gastric ridges and often filaments, and multiplying or metamorphosing by transverse fission to form the larval medusa.

III. CTENOPHORA.—Devoid of nematocysts, locomotion by means of vibratile plates, which are arranged in eight meridional rows. Tentacles when present only two in number, adradially placed on opposite sides of the body.

## THE HYDROMEDUSÆ.

The Hydromedusæ comprise some five fairly distinct orders:

I. ANTHOMEDUSÆ.—A more or less hemispherical umbrella, sometimes ovoid or conical; velum usually well developed, affording an effectual swimming organ, because of which these medusæ are characterized by an active habit and quick vigorous movements lacking in many of the other orders. Sensory organs when present are on the bases of the tentacles as pigmented, ocellate structures, probably visual in function. Otocysts are entirely lacking in this order. The radial canals are usually four in number, rarely six or eight. Gonads are developed and borne on the walls of the manubrium, rarely extending somewhat upon the proximal portions of the radial canals.—*Nemopsis.*

II. Leptomedusæ.—Compared with the Anthomedusæ the umbrella of medusæ of this order is usually flat and disk-like; velum smaller and more delicate, at times difficult to distinguish, so that in many of the species motion is somewhat sluggish, being produced as much through the general contraction of the umbrella as by the velum. Sensory organs, when present, are usually otocysts, rarely ocelli, more rarely both, or both may be lacking. Otocysts are usually borne between the bases of tentacles, sometimes upon the inner side of their bases, and are probably equilibrium organs rather than visual. Gonads are borne along the line of the radial canals, rarely extending to the manubrium and upon its sides.—*Tima*, *Nemopsis.*

III. Trachomedusæ.—Usually devoid of a polyp stage, though the recent determination of this in *Gonionemus*, by Perkins, suggests the possibility of its occurrence in others. Sensory organs, when present, are otocysts, entodermal in their origin, ocelli usually lacking. Gonads borne upon the subumbrellar surface of the radial canals, often throughout their entire length. Umbrella usually hemispherical or bell-shaped; marginal tentacles usually numerous.

IV. Narcomedusæ.—Somewhat flattish, or disk-shaped umbrella, with tentacles set in socket-like receptacles high on the exumbrellar surface; radial canals usually in the form of flat, pouch-like diverticula of the stomach.

V. Siphonophora.—Comprising free-swimming polymorphic colonies, which are produced by budding from a medusoid individual. Gonads produced in specialized medusoid gonophores which seldom become free from the colony. The Siphonophora are characterized by an extreme degree of specialization found nowhere else among the cœlenterates, so great indeed as to leave some doubt as to the homologies of some of the individuals.

## ANTHOMEDUSÆ.

Codonidæ.—Manubrium cylindrical; mouth simple, devoid of lobes or tentacles; gonads borne on the manubrium, but not radially divided; radial canals four, narrow; marginal tentacles four, unbranched.

Tiaridæ.—Manubrium quadrangular; mouth with four lobes, simple or fimbriated; gonads four or eight, radially disposed upon the manubrium; radial canals four, rather wide; marginal tentacles unbranched.

Margelidæ.—Manubrium quadrangular, mouth usually simple or with four plain lip-like lobes, and with four or more simple or branched oral tentacles; gonads four or eight, borne on the manubrium; radial canals four, usually narrow; marginal tentacles unbranched.

Cladonemidæ.—Manubrium usually quadrangular, mouth rarely simple, usually provided with oral lobes or tentacles; radial canals narrow; marginal tentacles variously feathered or branched.

## Family CODONIDÆ.

### KEY TO THE GENERA.

A. With two or four marginal tentacles, equally developed.
   1. Tentacles and manubrium long, the latter extending far beyond the velum; bell hemispherical .......... *Syncoryne*
   2. Tentacles rather short and stout, capitate ends, manubrium with one or more constrictions, sometimes extending slightly beyond the velum; bell often conical .... *Dipurena*
   3. Tentacles as in preceding, but clavate, and with a distinct ring of nematocysts between the base and club-like ends; bell rather high and with rounded projection. .......... *Dipurella*
   4. Tentacles closely coiled in swimming; bell high and with eight rows of nematocysts.. *Ectopleura*
   5. Tentacles only two at liberation, four in maturity; bell oval or hemispherical, its surface dotted with nematocysts .......... *Hydrichthys*
   6. Tentacles rudimentary; bell elongate, oval .. [illegible]
   7. Tentacles only two; bell hemispherical and with rounded apical projection . *Perigonimus*

B. With a single conspicuous tentacle, others rudimentary or unequally developed.
  8. Large tentacle stout and subtriangular; other three rudimentary; bell elongate oval or rectangular in outline; manubrium short and thick .......... *Euphysa*
  9. A single large, long tentacle, two very small, one rudimentary; bell hemispherical, slightly asymmetrical .......... *Corymorpha*
  10. A single greatly enlarged tentacle, with thick base, from which secondary medusæ are budded; bell evidently asymmetrical .......... *Hybocodon*

### **SYNCORYNE** Ehrenberg (in part, 1834).

### **Syncoryne mirabilis** (L. Agassiz). Pl. V, fig. 1.

*Sarsia mirabilis* L. Agassiz, Memoirs American Academy of Arts and Sciences, Vol. IV, 1849, p. 224.
*Coryne mirabilis* L. Agassiz, Contributions to the Natural History of the United States, Vol. IV, 1862, pp. 185, 340.
*Syncoryne mirabilis* Allman, Monograph of the Gymnoblastic Hydroids, 1871, p. 278.
*Sarsia mirabilis* Haeckel, System der Medusen, 1879, p. 17.

Bell subhemispherical, very transparent, varying from 6 to 12 mm. in diameter. Tentacles 4, very long and filamentous, but capable of great contraction. Manubrium long and pendulous, extending far beyond the velum, but highly contractile, often coiled within the bell. Mouth simple. Gonads borne on the manubrium, at maturity enlarging this organ till it fills the bell cavity. A very common medusa, ranging in season from February to May.

*Colors.*—Bell very transparent, manubrium pale greenish, tentacular bulbs greenish about a brownish center, within which is located the black ocellus.

*Distribution.*—Fairly common throughout the region; reported by Fewkes as somewhat rare at Newport.

### **Syncoryne reticulata** (A. Agassiz).

*Syndictyon reticulatum* A. Agassiz, in L. Agassiz, Contributions Natural History United States, Vol. IV, 1862, p. 340. North American Acalephæ, 1865, p. 177.
*Syncoryne reticulata* Allman, Monograph of the Gymnoblastic Hydroids, 1871, p. 283.
*Syndyctyon reticulatum* Haeckel, System der Medusen, 1879, p. 21.

Medusa very similar to the preceding, but said to be distinguished in younger stages by the spirally disposed nematocysts about the distal portions of the tentacles, and by the reticulated disposition of the nematocysts over the exumbrella. These characters said to disappear after maturity, when the species is chiefly distinguished by the permanently red-brown ocelli.

This medusa has not been distinguished by the present writer, nor have I seen it reported by recent students of the group. This brief description is taken from A. Agassiz's account (North American Acalephæ, page 177–180).

*Distribution.*—Massachusetts Bay, Boston Harbor, Nahant (Agassiz, Clark).

### **Syncoryne producta** Hargitt. Pl. I, fig. 1.

*Coryne producta* Hargitt, American Naturalist, Vol. XXXVI, 1902, p. 550.

Bell high hemispherical or ovate, 1.5 mm. in long diameter by 1 mm. in short diameter; tentacles 4, rather long and with prominent basal bulbs, which are orange colored with a central black ocellus. Manubrium long and distinctively sarsian in character, projecting far beyond the velum, but capable of great contraction, its terminal portion bulb-like, basal portion forming a gastric pouch; mouth simple. Gonads medusoid and borne in a whorl about the base of the manubrium. This is the first member of the genus from this region or from American waters known to produce proliferous medusæ, as do Forbes's species, *Sarsia gemmifera* and *S. prolifera*.

*Colors.*—Bell very transparent; manubrium with basal portion orange; terminal bulbs proximal light sky-blue; distal green; tentacle bulbs orange, margined with delicate greenish; ocelli black.

*Distribution.*—A single specimen taken at Woods Hole.

### **DIPURENA** McCrady (1857).

### **Dipurena strangulata** McCrady. Pl. I, fig. 2.

*Dipurena strangulata* McCrady, Proceedings of the Elliott Society of Natural History, Vol. I, 1857, p. 33. L. Agassiz, Contributions to the Natural History of the United States, Vol. IV, 1862, p. 341. A. Agassiz, North American Acalephæ, 1865, p. 181. J. W. Fewkes, Bulletin of the Museum of Comparative Zoology, Vol. VIII, 1881, p. 155.
*Slabberia strangulata* Haeckel, Prodromus Systemæ Medusarum, 1877, No. 15.
*Dipurena strangulata* Haeckel, System der Medusen, 1879, p. 23.

This medusa was first described by McCrady from Charleston Harbor. The only record of its subsequent occurrence within that region is that by Fewkes above cited. For several years I have taken medusæ at Woods Hole which differ in no essential respect from McCrady's species and which I consider identical.

Bell subhemispherical to half ovoid, very transparent, with firm walls; marginal tentacles 4, stout, rather stiff, and with evident terminal knobs, basal bulbs prominent, each with a single black ocellus on its outer central surface; manubrium usually long, though highly contractile and distinguished by one or more rather sharp constrictions, usually one at the base and another about the middle, suggesting the specific designation. Mouth simple or slightly lobed.

*Colors.*—Body of manubrium bright green margined with red or pink; tentacular bulbs reddish orange, terminal knobs bright reddish.

*Distribution.*—Common at Woods Hole, rare at Newport (Fewkes).

### **Dipurena conica** A. Agassiz.

*Dipurena conica* A. Agassiz, in L. Agassiz's Contributions to the Natural History of the United States, Vol. IV, 1862, p. 341; North American Acalephæ, 1865, p. 181.
*Slabberia conica* Haeckel, Prodromus Systemæ Medusarum, 1877, No. 16.
*Dipurena conica* Haeckel, System der Medusen, 1879, p. 24.

Bell conical to hemispherical, with rather firm aboral thickening; marginal tentacles 4, of same character as in preceding species; manubrium indistinguishable from preceding; mouth similar.

*Colors.*—Indistinguishable from preceding.

*Distribution.*—Buzzards Bay, Vineyard Sound, etc.

Medusæ answering in every particular to Agassiz's description have been taken constantly for many years, but associated with individuals which as clearly correspond with the preceding; and, what is more significant, these two forms graduate imperceptibly into each other in all essentials of shape, structure, etc. It seems altogether probable, therefore, that we have here simply a varietal form, which would hardly justify specific separation, and should probably be included under the above species.

### **DIPURELLA** Hargitt (1902).

Resembling in some respects the preceding genus, these medusæ have marked differences in shape of bell, form of manubrium, and certain aspects of the tentacles, demanding generic distinction.

### **Dipurella clavata** Hargitt. Pl. I, fig. 3.

*Dipurella clavata* Hargitt, Biological Bulletin, Vol. IV, 1902, p. 19.

Bell rather high, subrectangular in profile, with slight apical projection; sides of bell almost straight, thin, flexible, and capable of marked contraction both in long and short diameters. Surface of the exumbrella dotted rather promiscuously with clusters of nematocysts. Radial canals 4, rather wide and simple. Tentacles 4, unequally developed in the type specimen. This difference would seem to be due to immaturity, as is also indicated by the exumbrellar nematocysts. It will be noted from a comparison of the figures of this medusa and *Dipurena* that there is more or less similarity in the form and general aspects of the tentacles. Both are rather stout and rigid, both end in clavate knobs, both have similar basal bulbs. On the other hand the knobs of *Dipurella* are of a heavier and more club-like character, and in addition there is about the median portion of each tentacle a ring of nematocysts which are wholly peculiar to the latter species. The manubrium is sessile, rather short, with large gastric basal portion; mouth simple or slightly lobed.

*Colors.*—Chiefly restricted to the tentacles; terminal knobs with bright carmine-red center tinged with delicate green; basal bulbs duller orange, red, or brown; ocelli black; manubrium tinged with pale green.

*Distribution.*—A single specimen taken in Great Harbor. Size small, 2 mm. in height by about 1.5 mm. in width.

### ECTOPLEURA L. Agassiz (1862).

**Ectopleura ochracea** A. Agassiz. Pl. II, fig. 1.

*Ectopleura ochracea* A. Agassiz, in L. Agassiz, Contributions Natural History United States, Vol. IV, 1862, p. 343; North American Acalephæ, 1865, p. 191. Haeckel, System der Medusen, 1879, p. 22.

Bell elongate ovoid or pyriform, with thick aboral mesoglea, sides of uniform thickness, exumbrellar surface with eight meridional bands of nematocysts uniting at the apex. Radial canals 4, narrow, and communicating with a well-defined marginal canal. Tentacles 4, usually long and filamentous, though often coiled and contracted when taken in the tow. Size from 2 to 4 mm. in long diameter, by about half as wide. Manubrium large and flask-shaped.

*Colors.*—Manubrium yellowish on base and oral end, the latter often reddish; central portion reddish to pink. Tentacular bulbs of similar color; ocelli reddish brown.

*Distribution.*—Common throughout the region in midsummer.

### HYDRICHTHYS Fewkes (1888).

**Hydrichthys mirus** Fewkes.

*Hydrichthys mirus* Fewkes, Bulletin Museum Comparative Zoology, Vol. XIII, 1888, p. 224.

Bell oval or subspherical, its outer surface dotted here and there with clusters of nematocysts. Marginal tentacles 4 in adult specimens; only 2 when first liberated; tentacular bulbs reddish in color, but devoid of ocelli. Manubrium cylindrical, rather short; mouth simple.

*Colors.*—Bulbs of tentacles reddish-brown; manubrium yellowish to orange.

*Distribution.*—A single record, so far as known to the present writer, that of Fewkes above cited; the medusa taken from a fish at Newport.

### PENNARIA Goldfus (1820).

**Pennaria tiarella** Ayres. Pl. III[a].

*Globiceps tiarella* Ayres, Proceedings Boston Society of Natural History, Vol. IV, 1852, p. 193. L. Agassiz, Contributions to the Natural History of the United States, Vol. IV, 1862, p. 344.

*Eucoryne elegans* Leidy, Marine Invertebrates of New Jersey and Rhode Island, 1855, p. 4, in Journal of Academy of Sciences, Philadelphia, Vol. III.

*Pennaria tiarella* McCrady, in Proceedings of Elliott Society of Natural History, Vol. I, 1857, p. 153. A. Agassiz, North American Acalephæ, 1865, p. 187.

*Halocordyle tiarella* Allman, Monograph of the Gymnoblastic Hydroids, 1871, p. 369.

*Globiceps tiarella* Haeckel, System der Medusen, 1879, p. 39.

Bell high, elliptical or ovoid in outline; size 1.5 mm. high by 0.8 mm. broad. Radial canals 4 marked by lines of reddish pigment on the exumbrellar surface; marginal tentacles 4, very rudimentary. Manubrium spindle-shaped, about half as long as bell; mouth rudimentary, probably not functional. Gonads borne on manubrium and filling entire bell cavity at maturity. Sexual products discharged at once on liberation of the medusa from the hydroid—indeed, often before—in many cases the medusa never becoming free, but discharging the eggs or sperms and dying upon the branches. *Pennaria* seems to be just on the border line between the fixed and free gonophore phases not uncommon among the Tubulariidæ. I have elsewhere discussed this feature of the species in more detail. (Cf. American Naturalist, Vol. XXXIV, p. 390, et seq.)

*Colors.*—General color, pale rosy pink; manubrium, chocolate-brown, reddish pigment along lines of radial canals. Ova vary from creamy white to orange.

*Distribution.*—General throughout the region in shallower waters; less common from deep waters. One of the commonest of our hydromedusæ, and exhibiting in striking way the characteristic alternation of generations. As previously shown (op. cit.), *Pennaria* exhibits interesting seasonal and environmental variations.

Specimens of *P. gibbosa* from Florida and Porto Rico, compared with *P. tiarella*, show hardly sufficient differences to warrant specific distinctness.

---

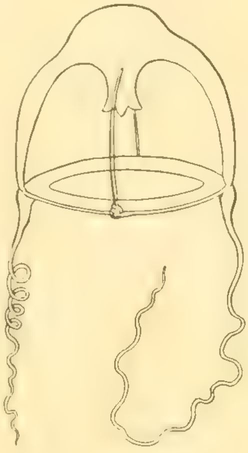
[a] Figs. 3 and 4 drawn from life by H. B. Bigelow.

### PERIGONIMUS Sars (1840).

#### Perigonimus jonesii Osborn & Hargitt. Text cut.

*Perigonimus jonesii* Osborn & Hargitt, American Naturalist, Vol. XVIII, 1894, p. 27. Hargitt, Mittheilungen Zoologischen Station, Neapel, Bd. 11, 1895.

Bell hemispherical, with slight apical projection, about as high as broad, 2 mm. or slightly more. Marginal tentacles 2, located on opposite sides, and with 2 additional tentacular bulbs at the intermediate points; tentacles highly retractile and often carried coiled within the bell cavity, especially when the medusa is disturbed. Velum well developed; manubrium short, subquadratic, and with simple, 4-lobed mouth. Gonads undeveloped in specimens taken, and showing no evidences of growth within a period of more than two weeks, during which they were kept in apparent health in the aquaria.



*Perigonimus jonesii.*

*Habitat.*—Found only on the legs and abdominal appendages of the common spider crab, *Libinia*, and taken from this source during several seasons.

*Distribution.*—Long Island Sound, originally taken at Cold Spring Harbor.

### EUPHYSA Forbes (1848).

#### Euphysa virgulata A. Agassiz.

*Euphysa virgulata* A. Agassiz, North American Acalephæ, 1865, p. 189. Haeckel, System der Medusen, 1879, p. 33.

Bell somewhat elongate oval or subrectangular in profile; tentacles 4, but unequally developed, one being much longer and heavier than the others; basal bulbs pinkish and extending upward along the radial canals for a short distance; manubrium short and thick, cylindrical, and with an accumulation of fat-like globules about its base; mouth simple; gonads borne upon the manubrium. In size the medusa is from 8 to 10 mm. in long diameter, slightly less in breadth.

*Colors.*—Bases of tentacles with bright pigment, extending up the radial canals; manubrium yellowish; bell transparent.

*Distribution.*—Nahant, Massachusetts Bay, Woods Hole.

### HYBOCODON L. Agassiz (1862).

#### Hybocodon prolifer L. Agassiz. Pl. II, fig. 2.

*Hybocodon prolifer* L. Agassiz, Contributions to the Natural History of the United States, 1862, Vol. IV, p. 243. A. Agassiz, North American Acalephæ, 1865, p. 193. Allman, Monograph of the Gymnoblastic Hydroids, 1871, p. 422. Haeckel, System der Medusen, 1879, p. 33.

Bell subhemispherical, unsymmetrical, being humped upon one side adjacent to the single large tentacle, the latter having a heavy, thick base and affording support for the proliferous secondary medusæ which bud asexually therefrom. The tentacle is very long, the terminal two-thirds being abundantly supplied with rings of nematocysts. Manubrium rather short, cylindrical, and with simple mouth. Gonads on walls of manubrium, where the ova develop directly into actinulæ, several of which may be found in various stages of development at the same time.

Developing actinulæ and budding medusæ are found at the same time, usually during the early spring—March to May—though proliferous medusæ seem to arise almost constantly, being present on specimens taken in August. An examination of the histology of the gonads shows aspects of oogenesis and development almost exactly similar to those exhibited in *Pennaria*, *Corymorpha*, *Tubularia crocea*, and others. Egg cleavage is so similar to that found in the last-named species as to be almost indistinguishable during corresponding phases. Ova which become active and begin development show the same phenomena of absorption of their fellows as Doflein has pointed out in *Tubularia mesembryanthemum* and Allen in *T. crocea*. It is not clear how fertilization occurs, since the early development takes place wholly within the tissues of the manubrium, but it is presumably through the penetration of the ectoderm by the spermatozoon, as in several other tubularians.

*Hybocodon* is characterized by the presence of 5 meridional lines of orange or pinkish pigment over the exumbrella, two of them arising from the base of the large tentacle. Associated with these bands are batteries of nematocysts. A remarkable feature is the apparently gradual disappearance during late spring and summer of these bands, together with their nematocysts, both being wholly absent in specimens taken in August.

*Colors.*—Bell transparent; orange bands over the exumbrella, on base of tentacle, and on knobs at distal ends of radial canals; manubrium similarly colored at its base and oral end.

*Distribution.*—General throughout the region, though usually in greatest abundance within limited areas along the coast.

### **Hybocodon pendula** (L. Agassiz). Pl. II, fig. 3.

*Corymorpha pendula* L. Agassiz, Contributions to Natural History United States, Vol. IV, 1862, p. 276. A. Agassiz, North American Acalephæ, 1865, p. 192.

*Hybocodon pendula* Haeckel, System der Medusen, 1879, p. 34; Hargitt, Biological Bulletin, Vol. IV, 1902, p. 20.

*Monocaulus pendulus* Allman, Monograph Gymnoblastic Hydroids, 1871, p. 397.

Bell similar to that of preceding species, though but slightly unsymmetrical, medusa slightly larger; tentacles unequally developed, one rather large, the others much smaller, one being sometimes rudimentary. Manubrium very similar to that of preceding, and with gonads borne on the surface as in the former.

The hydroid of this medusa I have frequently taken at various places in and about Vineyard Sound and Muskeget Channel, and off Chatham, usually from sandy bottoms and at considerable depths. It is a most beautiful form and lives quite well for a few days in the aquarium. L. Agassiz stated that its medusæ were not liberated, but A. Agassiz later claimed this to have been a mistake and reported having taken the medusæ, though without direct evidence of their relation to the hydroid. Such has been my own experience. Hydroids with medusæ in all stages of development have often been taken, as have also free medusæ, from waters near where the hydroids were dredged, and at the same time, so that there seems to be little doubt as to their relations.

*Colors.*—Very similar to those of *H. prolifer*, though less bright.

## Family TIARIDÆ.

KEY TO THE GENERA.

A. Marginal tentacles two or four.
  1. Marginal tentacles four; bell with rounded apical projection ........ *Protiara*
  2. Marginal tentacles two; bell with rather sharp apical projection ........ *Stomotoca*
B. Marginal tentacles numerous.
  3. Bell with globular apical projection.. ........ *Turris*
  4. Bell without globular apical projection ........ *Turritopsis*

### **PROTIARA** Haeckel (1879).

Four perradial tentacles; manubrium with broad sessile base; gonads borne in four masses on the angles of the manubrium.

This genus was established by Haeckel to distinguish a medusa of synthetic characters, somewhat intermediate between the Codoniidæ and the Tiaridæ and indicated by him as the prototype of the latter family. I have elsewhere described briefly a medusa taken in the Woods Hole region which has characters quite similar to the genus under consideration.

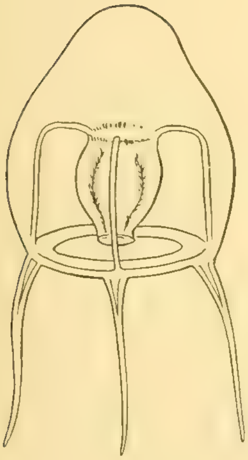
### **Protiara haeckeli** Hargitt. Text cut.

*Protiara haeckeli* Hargitt, Biological Bulletin, Vol. IV, 1902, p. 17.

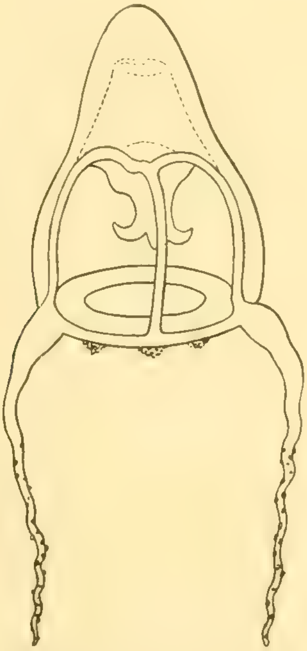
Bell half-ovoid, with rather elongated apical projection; tentacles four, rather stout, slightly longer than bell, and with enlarged basal bulbs, the latter devoid of ocelli; velum well developed; manubrium prominent, gastric portion quadratic in cross section, and with the milk-white gonads borne on its walls; mouth simple with slightly lobed lips. Height of bell from 2 to 4 mm. by slightly more than half as broad. Ontogeny entirely unknown.

*Colors.*—Bell very transparent, manubrium and gonads milk-white.

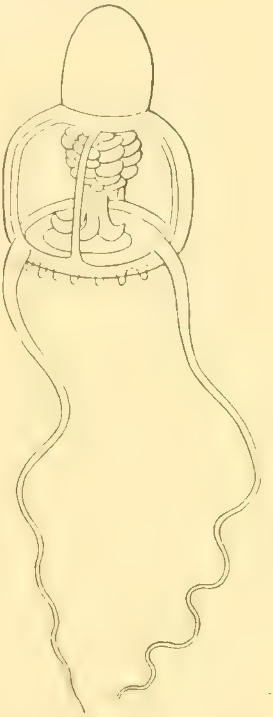
*Distribution.*—Off Gay Head and Nomans Land, Vineyard Sound. Several specimens were taken on two occasions during the summer (July and August) in the same general region.



*Protiara haeckeli.*



*Stomotoca apicata,* ♂. (After Mayer.)



*Stomotoca apicata,* ♀. (After Mayer.)

## STOMOTOCA L. Agassiz (1862).

### Stomotoca apicata (McCrady). Text cuts.

*Saphenia apicata* McCrady, Proceedings Elliott Society of Natural History, Vol. I, 1857, p. 129

*Stomotoca apicata* L. Agassiz, Contributions Natural History United States, Vol. IV, 1862, p. 347.

*Dinamatella cavosa* Fewkes, Bulletin Museum Comparative Zoology, Vol. VIII, 1881, p. 151.

*Amphinema apicatum* Haeckel, System der Medusen, 1879, p. 50.

This species presents rather striking sexual dimorphism; the male has a long tapering apical projection which is solid, while in the female it arises abruptly from the bell and is hollow. The colors of the two sexes also differ, the male showing a preponderance of green, while the female is dull brownish ocher. Radial canals wide, tentacles two, highly contractile and with prominent basal bulbs; rudimentary bulb-like processes at the intermediate radial points, and often interradial bulbs about the margin; manubrium large, quadratic in section, with broad base; gonads in four masses on manubrial walls; mouth with prominent everted lobes. -Ontogeny unknown.

Colors as indicated above. Distribution chiefly southward in Woods Hole region; Newport, R. I., etc. Mid-summer.

### Stomotoca rugosa Mayer.

*Stomotoca apicata* Fewkes, Bulletin Museum of Comparative Zoology, Vol. VIII, 1881, p. 152

*Amphinema apicatum*, Brooks, Studies Biological Laboratory Johns Hopkins University, Vol. II, 1883, p. 473.

*Stomotoca rugosa* Mayer, Bulletin Museum Comparative Zoology, Vol. XXXVII, 1900, p. 32.

Shape of bell similar to that of preceding species, but of larger size, 5 mm. high by 3 mm. broad, and having a rugose manubrium. Tentacles similar in size and character to preceding; radial and circular canals wide, all with undulating outlines; velum well developed. The sexual dimorphism noted in the preceding seems to be lacking in this species.

*Ontogeny.*—Brooks has described this medusa (cf. op. cit.), as derived from a hydroid which he identified as *Perigonimus minutus* Allman.

*Colors.*—Bell transparent; tentacles and bulbs reddish as is also the manubrium.

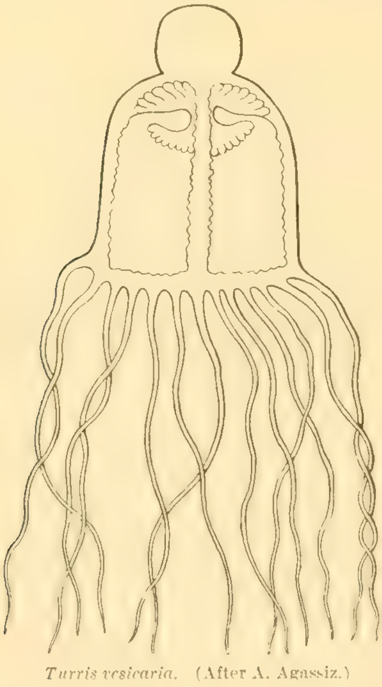
*Distribution.*—Similar to the preceding.

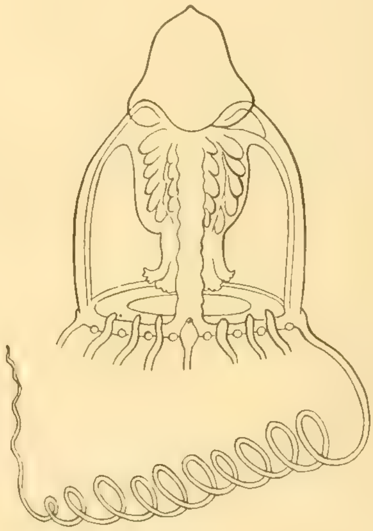
### TURRIS Lesson (1837).

#### **Turris vesicaria** A. Agassiz. Text cut.

*Turris vesicaria* A. Agassiz, Proceedings Boston Society of Natural History, Vol. IX, 1862, p. 97; North American Acalephæ, 1865, p. 164.
*Catablema vesicarium* Haeckel, System der Medusen, 1879, p. 64.

Medusa high, bell-shaped or hemispherical, with a prominent globular apical projection; tentacles numerous, each with broad basal enlargement bearing a single ocellus, and tapering to filamentous ends; manubrium large and with prominent crenulated oral lobes; gonads borne on base of manubrium and extending somewhat upon the four radial canals. Edges of the latter and of the marginal canal irregular or jagged.


*Turris vesicaria.* (After A. Agassiz.)


*Turris episcopalis.* (After Fewkes.)

*Colors.*—Bell transparent, manubrium and gonads dull yellowish.

*Distribution.* Nahant.

I have never taken this medusa, and the above description is condensed from that of A. Agassiz, who reports having taken it but once, and supposes it to be somewhat rare.

#### **Turris episcopalis** (Forbes). Text cut.

*Oceania episcopalis* Forbes, British Naked-eyed Medusæ, 1848, p. 27.
*Turris episcopalis* Fewkes, Bulletin Museum Comparative Zoology, Vol. VIII, 1881, p. 147.

Medusa shaped somewhat like an inverted teacup and with a rather sharp apical projection. Radial canals 4, wide and with jagged edges; marginal tentacles 16, long and highly contractile, with very short interposed tentacle-like structures; the long tentacles have prominent triangular bases, at the apex of which are borne bright crimson ocelli; between the bases of the long tentacles are 3 short tentacular processes and on each of these also is an ocellus, of color similar to those on the long tenacles.

All the tentacular organs are hollow, and have smooth surfaces. Manubrium large, with wide base. Gonads borne in conspicuous masses upon the upper portion of the manubrium; mouth large and with prominent, everted lobes.

*Colors.*—Bell transparent, pale milky white, tentacles pale yellow, ocelli crimson.

*Distribution.*—Newport, R. I.

This medusa is among the larger of the anthomedusæ and is said to be one of the most beautiful. I have not seen it, however, and the above description is condensed from that of Fewkes.

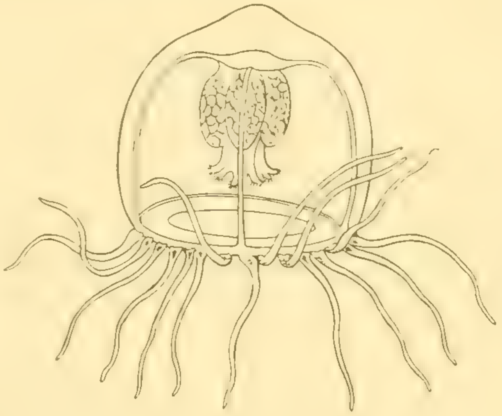
### TURRITOPSIS McCrady (1857).

### Turritopsis nutricula McCrady. Text cut.

*Turritopsis nutricula* McCrady, Proceedings of Elliott Society of Natural History, Vol. I, 1857, p. 127. L. Agassiz, Contributions to the Natural History of the United States, Vol. IV, 1862, p. 347. A. Agassiz, North American Acalephæ, 1865, p. 167. Haeckel, System der Medusen, 1879, p. 66.

*Modeeria multitentaculata* Fewkes, Bulletin Museum Comparative Zoology, Vol. VIII, 1881, p. 149.

*Turritopsis nutricula* Mayer, Bulletin Museum Comparative Zoology, Vol. XXXVII, 1900, p. 38.



*Turritopsis nutricula.*

Medusa high-hemispherical, with rather thin walls; radial canals four, narrow; velum well developed. Marginal tentacles numerous and of equal size, each with a dark brown ocellus on the inner side of its base. Tentacles usually long and highly contractile. Manubrium large and when bearing gonads on its basal portion fills nearly half the upper part of the bell. Mouth large and with four pairs of knobs plentifully loaded with nematocysts.

*Ontogeny.*—Brooks has described the development of this species in his memoir on North American Hydromedusæ.

*Colors.*—Bell transparent; tentacles with brownish bases; ocelli dark brown or blackish; gonads cinnamon-brown; manubrium dull yellow, sometimes streaked with brown or orange.

*Distribution.*—Occasionally taken at Woods Hole, Vineyard Sound, and southward.

## Family MARGELIDÆ.

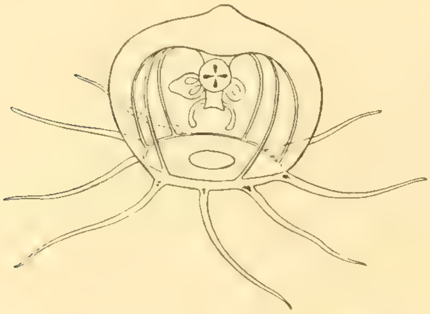
KEY TO THE GENERA.

| | |
|---|---|
| 1. Marginal tentacles 8, rarely 4, symmetrically disposed | *Dysmorphosa*<br>*Podocoryne* |
| 2. Marginal tentacles 8, rudimentary | *Stylactis* |
| 3. Marginal tentacles 8 to 16 | *Willia* |
| 4. Tentacles in 8 clusters | *Lizzia* |
| 5. Tentacles in 4 clusters | *Bougainvillia* |
| 6. Tentacles in 4 clusters, each margined by an erect, clavate pair | *Nemopsis* |

## DYSMORPHOSA[a] Philippi (1842).

### Dysmorphosa (?) fulgurans A. Agassiz. Text cut.

*Dysmorphosa fulgurans* A. Agassiz, North American Acalephæ, 1865, p. 163. Haeckel, System der Medusen, 1879, p. 77.



*Dysmorphosa fulgurans.* (After A. Agassiz.)

Bell subhemispherical, with a slight conical apical projection; radial canals 4, simple and narrow; marginal tentacles 8 in adult specimens, only 4 in young; symmetrically disposed; manubrium of medium size, its oral end provided with 4 rather prominent tentacles; secondary medusæ budded from the body of the manubrium in great numbers, this apparently the chief mode of reproduction, as I have not found the sexual products at any time. A. Agassiz says the number of medusæ thus budded becomes so great at times as to afford a splendid phosphorescence. Ontogeny, not known with certainty.

*Colors.*—Bell transparent, bases of tentacles and tip of manubrium reddish orange, pigment at base of tentacles probably ocellate in nature. Young medusa buds pale bluish by reflected light.

*Distribution.*—Common generally throughout the region in July and August.

## PODOCORYNE[a] Sars (1846).

### Podocoryne carnea Sars. Pl. IV, fig. 5.

*Podocoryne carnea* Sars, Fauna Littoralis Norvegiæ, Tome 1, p. 4, 1846. Krohn, Archiv für Naturgeschichte, Bd. XVII, 1851, p. 226. Hincks, British Hydroid Zoophytes, 1868, p. 29. Allman, Monograph Gymnoblastic Hydroids, 1871, p. 349. *Dysmorphosa carnea* Haeckel, System der Medusen, 1879, p. 77

General form very similar to the preceding species, with which it has been confused, unless upon fuller knowledge of the entire life history it should appear that the two forms are but dimorphic phases of one species. Their occurrence in the same region and season, however, makes this possibility somewhat doubtful.

Bell hemispherical with low arched aboral portion, entire exumbrella dotted with scattered clusters of nematocysts in young which disappear in the adult; 1 to 3 mm. in height and slightly more than half as broad. Marginal tentacles 4 in young medusa, but 4 additional interradial ones appear early, always remaining shorter than the perradials, however. Manubrium well developed, usually quadrate in section and with 4 oral tentacles which are tufted with clusters of nematocysts. Gonads borne on base of manubrium and apparently approaching maturity when the medusa is liberated from the hydroid.

*Colors.*—Bell very transparent, base of manubrium reddish-brown, gonads pale bluish, bright reddish-brown spots on perradial tentacular bases, duller ones on the interradials. It is somewhat doubtful whether these pigment spots are true ocelli.

*Ontogeny.*—Derived directly from the hydroid *Podocoryne*, the life cycle being easily traced on specimens kept in aquaria.

*Distribution.*—Generally the same as the preceding species and during essentially the same season.

---

[a] There can hardly be serious doubt as to the identity of these genera. Were there certainty as to the hydroid described by Philippi, the name *Dysmorphosa* should have recognition. In view of reasonable doubt on this point and the predominance of Sars' name in the literature, it seems best to give it right of way. Uncertainty as to ontogeny may warrant the former for Agassiz's species.

### LIZZIA Forbes (1848).

#### **Lizzia grata** A. Agassiz. Pl. I, fig. 4.

*Lizzia grata* A. Agassiz, Proceedings Boston Society of Natural History, Vol. IX, 1862, p. 99. Fewkes, Bulletin Museum Comparative Zoology, Vol. VIII, 1881, p. 142. A. Agassiz, North American Acalephæ, 1865, p. 161.
*Margellium gratum* Haeckel, System der Medusen, 1879, p. 95.

Bell subconical with high, rounded apical projection. Marginal tentacles in 8 clusters, perradial clusters with usually 5 tentacles, interradials usually 3 in mature specimens, fewer in young. There are no ocelli. Manubrium of moderate size with 4 rather prominent oral lobes, which are slightly branched. Gonads form prominent clusters on the basal portion of the manubrium. This medusa, like *Dysmorphosa fulgurans*, produces medusæ by asexual budding from the body of the manubrium. Specimens are found with secondary medusæ in all stages of development. Like the species just cited, this form does not seem to produce sexual products and medusæ at the same time.

*Ontogeny.*—So far as known to me the hydroid stock of this medusa has not been traced. The phases in medusoid budding have been studied by Haeckel, Agassiz, Fewkes, and Forbes, and observations have been made by Claparede (Zeit. f. Wiss. Zool., Bd. X) on the development of the egg. The tentacles arise first from the perradial points, 3 from each; this is followed by the appearance of a single tentacle at each of the interradial points, to which are added later 2 more tentacles; finally 2 tentacles are added to each of the primary sets. It should be noted, however, that this rule has exceptions, considerable variation appearing in both the number and the order of appearance of the tentacles.

*Colors.*—Bell very transparent, tentacular bases pinkish, tending to brown and even blackish in rare cases.

*Distribution.*—Fairly common throughout the region. (Nahant, Massachusetts Bay, A. Agassiz; Newport, Fewkes.) I have repeatedly taken this medusa at Woods Hole, both in the open tow and with a small dip net in the eel pond. April to August.

### BOUGAINVILLIA Lesson (1836).

#### **Bougainvillia carolinensis** (McCrady), Pl. II, fig. 4.

*Hippocrene carolinensis* McCrady, Proceedings Elliott Society Natural History, Vol. I, 1857, p. 164.
*Margelis carolinensis* L. Agassiz, Contributions Natural History United States, Vol. IV, 1862, p. 344. A. Agassiz, North American Acalephæ, 1865, p. 156.
*Bougainvillia carolinensis* Allman, Monograph Gymnoblastic Hydroids, 1871, p. 316.
*Margelis carolinensis* Haeckel, System der Medusen, 1879, p. 89.

Bell subspherical, with very thick walls of great transparency; radial canals 4, very narrow. Marginal tentacles in 4 clusters of from 2 to 15 each, varying with age, arranged about a finely pigmented triangular base. Velum well developed; manubrium rather long and with dichotomously branching oral tentacles; gonads borne on walls of manubrium.

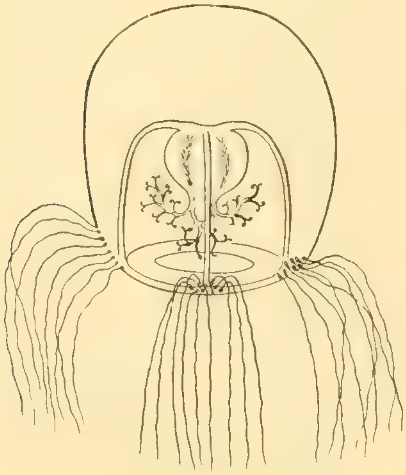
*Ontogeny.*—The medusa is derived directly from the hydroid of the same name. When first liberated the medusa is small, with rather thin-walled, hemispherical bell, and but 8 radial tentacles, 2 at each point. As growth takes place the bell becomes spherical and the mesoglea becomes greatly thickened, particularly over the aboral region. The oral tentacles, which at first are single, soon bifurcate, and this process repeats itself about three times, forming a somewhat complete series of oral tentacles. The adult medusa is from 8 to 10 mm. in diameter.

*Colors.*—The triangular pad from which the tentacles originate is bright reddish with green borders, the ocelli as many as the tentacles, forming a crescent of black points. The manubrium is of similar colors, pinkish about the base, bordered with green and with streakings of the same colors running lengthwise. There is, however, great variation in the color markings on this medusa.

*Distribution.*—Common generally throughout the region, though chiefly limited to shallower waters, where the hydroid evidently finds favorable environmental conditions. June to September.

### **Bougainvillia superciliaris** L. Agassiz. Text cut.

*Hippocrene superciliaria* L. Agassiz, Memoirs American Academy of Arts and Sciences, Vol. III, 2d series, 1849, p. 250 Stimpson, Marine Invertebrates of Grand Manan, 1853, p. 11, in Smithsonian Contributions to Knowledge, Vol. VI
*Bougainvillia superciliaris* L. Agassiz, Contributions to Natural History United States, Vol. IV, 1862, p. 289 and 344. A. Agassiz, North American Acalephæ, 1865, p. 153.
*Hippocrene superciliaris* Haeckel, System der Medusen, 1879, p. 92.



*Bougainvillia superciliaris.*

In general form and characteristics very similar to the preceding species, but of larger size and differing somewhat in shape and in the complexity of the oral tentacles as well as the disposition of the gonads. The marginal tentacles are also more numerous and of greater length. The manubrium is shorter and broader, and the gonads are crowded about its base instead of near the oral end, as in the former species. Size from 8 to 12 mm. in diameter in maturity.

*Colors.*—Less bright than in preceding species; sensory pads dull yellowish to orange, ocelli black, manubrium similarly colored, reddish orange distally.

*Distribution.*—Similar to that of preceding, but often taken from greater depths and farther offshore. June to September.

### **Bougainvillia gibbsi** Mayer.

*Bougainvillia gibbsi* Mayer, Bulletin Museum Comparative Zoology, Vol. XXXVII, 1900, p. 5.

Medusa very similar to *B. carolinensis*, distinguished by Mayer by the relatively greater height of bell and by the shorter and broader manubrium. Moreover, the size is smaller, the marginal tentacles fewer in number, and the oral tentacles less complex.

Mayer records its occurrence at Newport, from July to October. He gives ample description in the article cited.

## **WILLIA** Forbes (1848).

*Willsia* Forbes, British Naked-eyed Medusæ, 1848, p. 19.
*Willia* L. Agassiz, Contributions to Natural History of the United States, Vol. IV, 1862, p. 346.

### **Willia ornata** McCrady, Pl. I, fig. 5.

*Willsia ornata* McCrady, Proceedings Elliott Society of Natural History, Vol. I, 1857, p. 149.
*Willia ornata* A. Agassiz, North American Acalephæ, 1865, p. 171.
*Willia gemmifera* Fewkes, Bulletin Museum Comparative Zoology, Vol. IX, 1882, p. 299.
*Dyscannota dysdipleura* Haeckel, System der Medusen, 1879, p. 152.
*Willetta ornata* Haeckel, System der Medusen, 1879, p. 157.

Body of medusa rather low, bell-shaped, somewhat conical above, about twice as broad as high, and with rather firm walls. Radial canals only 4 at birth, later each of these branches as shown in the figure, finally resulting in from 12 to 16 terminal canals, which communicate with that of the margin. Tentacles likewise but 4 at birth, but increasing in number with the increase of radial canals, so that finally there may be 12 or more at maturity. Between the terminal branches of the canals are irregular lines of nematocysts, which pass upward on the outer surface of the bell for short distances. Manubrium well developed, mouth with 4 everted lobes. Gonads form prominent masses on the base of the manubrium, but never extend outward upon the radial canals. Ontogeny wholly unknown.

*Color.*—Ocelli reddish brown, gonads and manubrium pale greenish.

*Distribution.*—More or less common at irregular intervals. Occasionally taken in numbers in the Eel Pond and in the tow of the harbor.

Haeckel, in the System der Medusen (vide supra), has placed this form among the cannotid Leptomedusæ, which seems to me to be wholly without warrant in so far as its more fundamental characters are concerned, the branching radial canals, perhaps, excepted. As will be noted, its shape, tentacles, ocelli, etc., are all distinctively Anthomedusan, and I have therefore ventured to place it among the Margelidæ. When its ontogeny comes to be known a different assignment may be required.

### **NEMOPSIS** L. Agassiz (1849).

#### **Nemopsis bachei** L. Agassiz. Text cut.

*Nemopsis bachei* L. Agassiz, Memoirs American Academy Arts and Sciences, Vol. IV, 1849, p. 289; Contributions Natural History United States, Vol. IV, 1862, p. 345. A. Agassiz, North American Acalephæ, 1865, p. 149.
*Nemopsis gibbesi* McCrady, Proceedings Elliott Society Natural History, Vol. I, 1857, p. 160. Allman, Monograph Gymnoblastic Hydroids, 1871, p. 362.
*Nemopsis bachei* Haeckel, System der Medusen, 1879, p. 93.

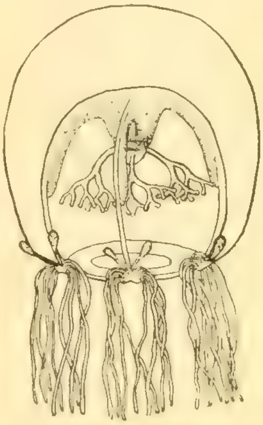
This medusa, while similar in general aspects to the species of *Bougainvillia* above described, has several very distinctive differences, such as the disposition of the gonads beneath the radial canals, and also the pair of clavate marginal tentacles which arch over the clusters of long tentacles.

It is specifically distinguished by the height and the thickness of the walls and upper portion of the bell. The marginal tentacles are in 4 clusters, arranged about a bulbous pad, with a distinct series of ocelli at their bases and each cluster with a pair of erect, clavate, tentacular bodies. As in *Bougainvillia*, the tentacles vary in size and number with age, averaging about 7 or 8 in each cluster in mature specimens, the ends usually appearing to have clavate enlargements. Manubrium similar to the species already referred to, mouth with 4 complexly branched tentacles which are capable of great contraction, so that they may become almost indistinguishable. Gonads borne on basal portion of manubrium and in course of development extending beneath the radial canals, almost or quite the entire length in many cases.

*Ontogeny.*—Unknown.

*Colors.*—Sensory bulbs yellowish orange, gonads yellowish.

*Distribution.*—Common throughout the region, ranging in season from June to September.



*Nemopsis bachei.*

### **STYLACTIS** Allman (1871).

#### **Stylactis hooperi** Sigerfoos.

*Stylactis hooperi* Sigerfoos, American Naturalist, Vol. XXXIII, 1899, p. 802.

Bell globular, slightly elongate, about 1 mm. in height. Marginal tentacles 8, rudimentary, symmetrically disposed about the margin. Ocelli absent. Manubrium large, devoid of oral tentacles or lobes. Gonads borne in general mass about the manubrium; products discharged at once upon liberation of the medusa.

*Ontogeny.*—Derived directly from a small hydroid, having its habitat upon the shell of a living snail, *Illyanassa obsoleta.*

*Distribution.*—Originally described from Cold Spring Harbor, Long Island. Likely to be found within the present region.

## Family CLADONEMIDÆ.

KEY TO THE GENERA.

A. Marginal tentacles four, two rudimentary .................................................. *Gemmaria*
B. Marginal tentacles two .................................................. *Corynitis*

### **GEMMARIA** McCrady (1857).

Four simple radial canals, at the distal exumbrellar terminus of which are 4 clusters or bands of nematocysts. Marginal tentacles 2, at opposite perradial points, each long and with various knob-like and stalked clusters of nematocysts.

### **Gemmaria cladophora** A. Agassiz.[a]

*Gemmaria cladophora* A. Agassiz, North American Acalephæ, 1865, p. 184. Haeckel, System der Medusen, 1879, p. 104.

Bell subhemispherical to conical, with walls of varying thickness over different regions, giving to the subumbrellar cavity a form differing from that of the exumbrella. Marginal tentacles 4, 2 rudimentary, the other 2 long and abundantly supplied with batteries of nematocysts, many of which are stalked. Manubrium well developed and with the gonads borne on its proximal portion; mouth simple, with 4 slightly everted lips, richly supplied with nematocysts. Ontogeny unknown or doubtful.

*Colors.*—Tentacles light brownish, with orange pigmentation at the bases.

*Distribution.*—Massachusetts Bay, Agassiz. Woods Hole.

## **CORYNITIS McCrady** (1857).

### **Corynitis agassizii** McCrady.[a]

*Corynitis agassizii* McCrady, Proceedings Elliott Society Natural History, Vol. I, 1857, p. 132.
*Gemmaria gemmosa* McCrady, op. cit., p. 49.
*Zanclea gemmosa* McCrady, op. cit., ibid.
*Halocharis spiralis* L. Agassiz, Contributions Natural History United States, Vol. IV, 1862, p. 239.
*Corynitis agassizii* A. Agassiz, North American Acalephae, 1865, p. 185; Allman, Monograph Gymnoblastic Hydroids, 1871, p. 287; Murbach, Quarterly Journal Microscopical Science, Vol. 42, 1899, p. 354.
*Corynctis agassizii* Haeckel, System der Medusen, 1879, p. 49.

Bell elongate hemispherical, slightly higher than broad, about 2 mm. in height when liberated. Marginal tentacles 2, long, with broad base, the entire tentacle rough with batteries of nematocysts, many of which are stalked and erect like vorticellæ, for which they might easily be mistaken upon casual examination. Radial canals 4, with rather conspicuous knots of nematocysts on the exumbrellar surface of their distal ends. Manubrium well developed, flask-like, with 4 oral lips, which are simple and slightly everted.

*Ontogeny.*—Derived directly from the hydroid stock, easily kept in aquaria. Habitat of hydroid, often on shell of *Mytilis*, fronds of sargassum, etc.

*Distribution.*—Buzzards Bay, Naushon (Agassiz); taken at docks of Fish Commission, Woods Hole, July.

## LEPTOMEDUSÆ.

In contrast with the Anthomedusæ, the Leptomedusæ are usually characterized by a flatter and more disk-like umbrella, which is also often of more delicate texture, or thinner and softer; the velum is usually less developed; tentacles usually more numerous and with a more general disposition about the margin. Gonads almost always borne upon the radial canals. Ocelli may or may not be present; sensory bodies usually of the vesiculate type—otocysts.

THAUMANTIIDÆ.—Radial canals 4 or 8; rarely more, always simple and unbranched. Tentacles usually numerous; ocelli usually present, otocysts usually lacking; manubrium usually short, with 4- to 8-lobed mouth; gonads in the form of undulating band-like organs along the radial canals.

CANNOTIDÆ.—Radial canals 4 or 6, branched or with lateral pinnate diverticula; tentacles usually very numerous; ocelli usually present, otocysts lacking; gonads usually spindle-like pouches on the radial canals; mouth with 4 or 6 oral lobes, which are sometimes rudimentary.

EUCOPIDÆ.—Radial canals always 4, simple and unbranched; tentacles usually numerous, at least 4; manubrium usually short and quadrate in section, with 4 oral lobes; ocelli absent, otocysts always present, usually 8 or more; gonads usually vesiculate bodies on the radial canals.

ÆQUOREIDÆ.—Radial canals numerous, 8 to 16 or more, often 100, simple; tentacles at least 8, usually very numerous; otocysts always present, 8 or more; ocelli absent; gonads usually ribbon-like; manubrium varying from very short to long, oral lobes usually numerous and variously plaited or folded.

---

[a] In a forthcoming paper (Mittheilungen Zoolischen Station Neapel, Bd. 16, 1904, S. 550), on some Hydromedusæ from the Bay of Naples, the present writer has taken occasion to express decided doubt as to the generic distinctness of these medusæ. It would seem more correct to regard them as related species.

## Family THAUMANTIIDÆ.

KEY TO THE GENERA.

A. Radial canals, 4; marginal tentacles numerous and with basal cirri...........*Laodicea*
B. Radial canals, 4; marginal tentacles numerous, but without basal cirri...........*Staurostoma*
C. Radial canals, 8; marginal tentacles numerous, without basal cirri...........*Melicertum*
D. Radial canals numerous, 16 to 32 or more; tentacles numerous, without basal cirri...........*Orchistoma*

### LAODICEA Lesson (1843).

**Laodicea calcarata** A. Agassiz. Text cut.

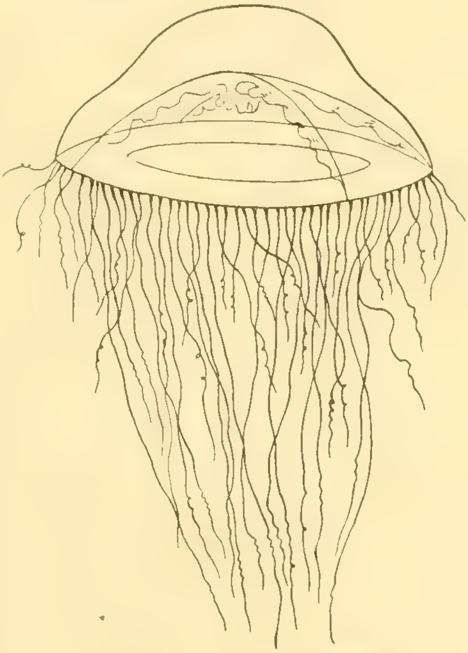
*Laodicea calcarata* A. Agassiz, in L. Agassiz, Contributions Natural History United States, Vol. IV, 1862, p. 350.
*Lafœa calcarata* A. Agassiz, North American Acalephæ, 1865, p. 122.
*Laodicea calcarata* Haeckel, System der Medusen, 1879, p. 134.

Bell broad, low dome-shaped, about twice as broad as high. Marginal tentacles very numerous and with swollen bases; interspersed with them are numerous tentacular spurs and cirri. Radial canals 4, along which the gonads are disposed in undulating masses. Manubrium rather short, with 4 plaited oral lobes. Velum well developed. Ocelli black pigment spots on bases of tentacles.

*Ontogeny.*—This medusa is derived from the hydroid stock of *Lafœa calcarata.* When first liberated it has but 2 tentacles, has a high, miter-shaped bell, and bears little resemblance to the adult. Growth seems to be rapid, other tentacles appear in rapid succession, and the bell gradually loses its earlier form and assumes the typical shape of the adult, with the various cirri, clubs, etc.

*Colors.*—Bell transparent; ovaries dull yellowish to brown; tentacles of similar color near the base, ocelli black.

*Distribution.*—Common throughout the region; usually taken in considerable numbers in the tow at Woods Hole during July and August.

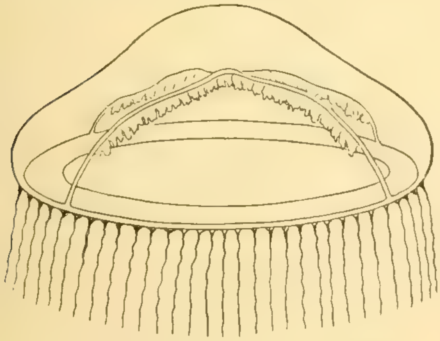


*Laodicea calcarata.* After A. Agassiz.

### STAUROSTOMA Haeckel (1879).

**Staurostoma laciniata** (L. Agassiz). Text cut.

*Staurophora laciniata* L. Agassiz, Memoirs American Academy Arts and Sciences, Vol. IV, 1849, p. 300; Contributions Natural History United States, Vol. IV, 1862, p. 351. A. Agassiz, North American Acalephæ, 1865, p. 136.
*Staurostoma laciniata* Haeckel, System der Medusen, 1879, p. 130.



*Staurostoma laciniata.* After L. Agassiz.

Bell low dome-shaped, about twice as broad as high, adult specimens attaining a diameter of 150 mm. or more, the average, however, only about 40 to 50 mm. Marginal tentacles very numerous; velum thin and delicate; manubrium indistinguishable, mouth early confluent with the genital folds, which are double along the ventral aspect of each radial canal, and are variously folded or crinkled; gonads develop within the complicated folds just mentioned. Ocelli present as violet pigment spots on the bases of the tentacles, more prominent on young specimens.

*Ontogeny* imperfectly known. Ova develop within the genital folds, the larvæ being later discharged as actinulæ.

*Colors.*—Bell transparent, with bluish milky tint, genital folds and oral ridges of similar tints.

*Distribution.*—Very common at times at Woods Hole and in adjacent waters. Agassiz reports the species extremely abundant at Nahant, Boston Harbor, and Massachusetts Bay during early spring, May and June. Its occurrence seems to be somewhat erratic, however, as I have taken specimens but twice within recent years.

### MELICERTUM[a] A. Agassiz (1862).

### Melicertum campanula A. Agassiz.

*Melicertum campanula* A. Agassiz, in L. Agassiz, Contributions to Natural History United States, Vol. IV, 1862, p. 349; North American Acalephæ, 1865, p. 130. Haeckel, System der Medusen, 1879, pp. 136-7.

Medusa bell-shaped, about as high as broad, capable of considerable change of form by erratic contractions of the umbrella. Marginal tentacles numerous in the adult, but the young resemble *Laodicea* in having but 2, later acquiring others. Radial canals 8 in the adult, only 4 in early life. Manubrium much as in *Laodicea*, oral lobes 8, with sinuous edges.

*Ontogeny.*—Medusa derived directly from the hydroid stock. Its development has been followed by A. Agassiz (op. cit., p. 134).

*Color.*—Bell light ocher; gonads and bases of tentacles brownish.

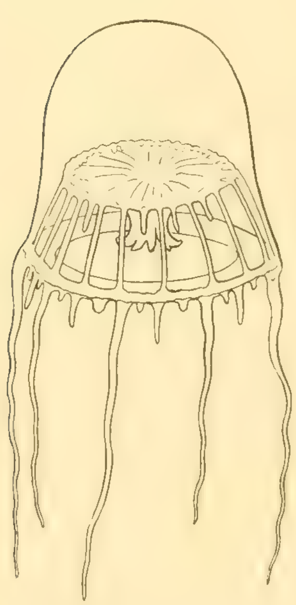
*Distribution.*—Massachusetts and northward (L. and A. Agassiz). So far as I am aware, the medusa has not been recorded at Woods Hole, though likely to be found at any time.

### ORCHISTOMA Haeckel (1879).

### Orchistoma tentaculata Mayer. Text cut.

*Orchistoma tentaculata* Mayer, Bulletin Museum Comparative Zoology, Vol. XXXVII, 1900, p. 8.

Mayer describes an immature specimen taken at Newport which has the following specific characters: Bell slightly flaring near the margin, gelatinous substance of upper portion very thick; marginal tentacles 32, in various stages of development, the longest about one and one-half times the height of bell and with hollow basal bulbs; radial canals, 16 functional ones, and 16 others in process of development; velum well developed; manubrium flat and shallow, with 8 lips; gonads undeveloped.



*Orchistoma tentaculata.* After Mayer

*Colors.*—Bell transparent, basal bulbs of tentacles a delicate green.

A medusa taken at Woods Hole, resembling this in many respects, I have considered as probably the young of *Rhegmatodes.*

---

[a] This generic term was apparently first employed by Oken in 1816 (Lehrb. der Naturgeschichte), and the very similar term *Melicerta* was proposed by Peron & Lesueur in 1809 in designating a Greenland medusa, presumably identical with that later described by Oken. In 1829 Eschscholtz, under the binomial here used, described with somewhat more detail and accuracy a medusa quite similar. Fabricius, however (Fauna Grœnlandica, 1780, p. 366), had used the same specific term in describing probably the same, or a similar medusa.

Haeckel has shown (System der Medusen, p. 139), that all these earlier accounts were either so inadequate or inaccurate as to leave serious doubt whether the medusa described by A. Agassiz (op. cit.) with critical detail was identical with that of the earlier accounts. He therefore proposes to credit both the generic and specific terms to the latter, and so designates them in his account (op. cit.). While in strict conformity with established usage the priority of the olde descriptions should have recognition, I have accepted Haeckel's version and leave a final adjustment for those having larger concern in problems of synonymy.

## Family CANNOTIDÆ.

Radial canals with numerous, pinnate, blind diverticula ........ *Ptychogena*

### PTYCHOGENA A. Agassiz (1865).

### Ptychogena lactea A. Agassiz.

*Ptychogena lactea* A. Agassiz, North American Acalephæ, 1865, p. 137. Haeckel, System der Medusen, 1879, p. 147.

Bell dome-shaped, about twice as broad as high, with rather thick walls; marginal tentacles numerous and filamentous; radial canals 4, lateral walls with numerous pouch-like diverticula; gonads variously folded and disposed beneath the canals; gastric cavity very flat, quadrate in form; mouth large, but devoid of definite lobes or lips. The medusa seems wholly devoid of sensory organs of any sort.

According to Agassiz, from whose account this description has been condensed, this is a deep-sea form, seldom coming to the surface, and when doing so apparently killed by the action of the light. Ontogeny unknown.

*Colors.*—Gonads, radial canals, and tentacles milk white.

*Distribution.*—Massachusetts Bay. The occurrence of this species within the immediate region of Woods Hole has not been reported, so far as I am aware, though it is likely to be taken at almost any time.

## Family EUCOPIDÆ.

KEY TO THE GENERA.

A. Marginal tentacles 4, sometimes with lateral cirri.
  1. Manubrium very long, extending beyond velum ........ *Eutima*
  2. Manubrium short, tentacles with lateral basal cirri ........ *Eucheilota*
  3. Manubrium short, tentacles devoid of basal cirri ........ *Clytia* (juv.)

B. Marginal tentacles 16 or more.
  4. Manubrium long, bell hemispherical ........ *Tima*
  5. Manubrium short, bell discoid, otocysts on bases of tentacles ........ *Obelia*
  6. Manubrium short, bell hemispherical, otocysts between bases of tentacles ........ *Clytia* or *Epenthesis*
  7. Manubrium short, oral lips variously fimbriated ........ *Tiaropsis*
  8. Manubrium short, 12 otocysts, tentacles with interposed cirri ........ *Phialis*
  9. Manubrium short quadrate, 16 marginal tentacles, with 16 interposed otocysts ........ *Epenthesis*
  10. Manubrium short, oral lobes plain, tentacles more than 16, two otocysts between each pair ........ *Oceania*

### EUTIMA McCrady (1857).

### Eutima mira McCrady. Pl. IV, fig. 1.

*Eutima mira* McCrady, Proceedings Elliott Society Natural History, Vol. I, 1857, p. 190. L. Agassiz, Contributions Natural History United States, Vol. IV, 1862, p. 360. A. Agassiz, North American Acalephæ, 1865, p. 116. Haeckel, System der Medusen, 1879, p. 191.

Medusa low, bell-shaped, about twice as wide as high, walls of bell very flabby, collapsing almost at once on being taken from the water. Size of adult 15 to 20 mm. in wide diameter. Marginal tentacles 4, very long and tapering to mere threads; each has a larger base with a pair of distinct cirri, though these are often so closely coiled as to escape attention. The velum is extremely delicate and perhaps little functional as an organ of locomotion, which is chiefly accomplished by rhythmic contractions of the entire bell. The manubrium is very long and pendulous, extending beyond the bell-margin two or three times its height. There is a long gelatinous peduncle, only the distal fifth constituting the gastric portion. The mouth is 4-lobed with strongly eversible lips, which form a disk-like organ not unlike the sucking disk of a leech. Gonads are borne along the median portion of the canals. The 8 otocysts are disposed about the margin of the bell, each containing several otoliths arranged in the form of crescents. Within each marginal quadrant there are also 3 rudimentary tentacles, each with its pair of cirri, which are also rudimentary, and slight swellings which appear to be of similar character. Ontogeny unknown.

*Colors.*—Bell very transparent, basal portion of tentacles pale green by reflected light, but a beautiful rose color by transmitted light, an interesting character which is possessed by many other medusæ. The distal portion of the manubrium is also greenish with a pale pinkish hue, and the same color though less distinct, is found in the gonads.

*Distribution.*—Very common at Woods Hole and in Vineyard Sound during August.

### **Eutima limpida** A. Agassiz.

*Eutima limpida* A. Agassiz, in L. Agassiz, Contributions Natural History United States, Vol. IV, 1862, p. 262; North American Acalephæ, 1865, p. 116. Haeckel, System der Medusen, 1879, p. 191.

This medusa is very similar in general aspects to the preceding species, if indeed it may not be found upon a more critical comparison to be identical, or perhaps a regional variety. Its size seems to me the only distinctive difference, though the tentacles are said to be shorter and to have the basal enlargement. Agassiz gives the size of adults as nearly 2 inches broad by about ½ inch high. He describes the otocysts also as of unusual size, easily visible to the naked eye.

In many years of collecting about Naushon I have never taken this medusa, nor do I find it reported by other collectors. May it not be that some unusually large specimens afforded the occasion for this specific distinction?

*Distribution.*—Buzzards Bay, Naushon (A. Agassiz).

## **EUCHEILOTA McCrady** (1857).

### **Eucheilota ventricularis** McCrady. Pl. IV, fig. 4.

*Eucheilota ventricularis* McCrady, Proceedings Elliott Society Natural History, Vol. I, 1857, p. 187.
*Eucheilota* L. Agassiz, Contributions to Natural History of United States, 1862, Vol. IV, p. 353.
*Eucheilota ventricularis* A. Agassiz, North American Acalephæ, 1865, p. 74. Haeckel, System der Medusen, p. 179, 1879.

Bell subhemispherical, broader than high. Marginal tentacles 4 perradial, with 4 somewhat rudimentary interradial, each set with a pair of basal cirri. The interradial tentacles afterward develop and adradial tentacles appear with later maturity, but none of the specimens taken by me showed these, and they are therefore absent in the figure given. Velum well developed. Gonads in spindle-like masses on the distal third of the radial canals. Ontogeny unknown.

*Colors.*—Bell transparent, tentacular bases and manubrium bright green by reflected light.

*Distribution.*—Fairly common in the waters adjacent to Woods Hole, and at Newport (Fewkes).

### **Eucheilota duodecimalis** A. Agassiz. Pl. IV, fig. 3.

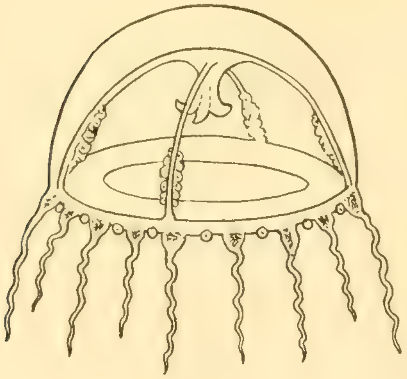
*Eucheilota duodecimalis* A. Agassiz, in L. Agassiz, Contributions Natural History United States, Vol. IV, 1862, p. 353; North American Acalephæ, 1865, p. 75.
*Phialium duodecimale* Haeckel, System der Medusen, 1879, p. 180.

Medusa similar in form to the preceding species, but distinguished by having but 4 long tentacles with their lateral cirri, and by the presence of 12 otocysts, 3 between each two tentacles.

*Distribution.*—Similar to the preceding species.

## **CLYTIA Lamouroux** (1812).

### **Clytia bicophora** L. Agassiz. Text cut.


*Clytia bicophora.*

*Clytia bicophora* L. Agassiz, Contributions to Natural History of United States, Vol. IV, 1862, pp. 304, 354. A. Agassiz, North American Acalephæ, 1865, p. 78.
*Epenthesis bicophora* Haeckel, System der Medusen, 1879, p. 184.

Medusa variable in form and other characters with development, at first inclined to be globular, later hemispherical. Marginal tentacles at first but 4; at maturity, 16. Velum fairly well developed, though narrow. Otocysts 8, disposed on either side of the perradial tentacles.

*Ontogeny.*—From hydroid *Clytia bicophora.*

*Colors.*—Bell, transparent; ovaries and tentacle bases, brownish.

*Distribution.*—Not especially abundant, though frequently taken at various points within the region. Frequent in the tow at Woods Hole.

### **Clytia nolliformis** (McCrady).

*Campanularia nolliformis* McCrady, in Proceedings Elliott Society of Natural History, Vol. I, 1857, p. 194.
*Campanularia volubilis* Leidy, Marine Invertebrates, New Jersey and Rhode Island, 1855, p. 6.
*Clytia cylindrica* L. Agassiz, Contributions to Natural History of United States, Vol. IV, 1862, p. 306.
*Platypixis cylindrica* A. Agassiz, North American Acalephæ, 1865, p. 80.
*Epenthesis bicophora* Haeckel, System der Medusen, 1879, p. 184.

This medusa resembles the preceding species so closely in most respects that Haeckel has included both under his *Epenthesis bicophora*, and it seems likely that they are identical. Only occasionally have I taken a specimen that seemed to differ sufficiently to warrant separate classification, though the hydroids seem to be fairly distinct.

Distribution as of preceding.

### **TIMA Eschscholtz** (1829).

### **Tima formosa** L. Agassiz. P. IV, fig. 2.

*Tima formosa* L. Agassiz, Contributions to Natural History of United States, Vol. IV, 1862, p. 362. A. Agassiz, North American Acalephæ, 1865, p. 113. Haeckel, System der Medusen, 1879, p. 205. Fewkes, Bulletin Museum Comparative Zoology, Vol. VIII, 1881, p. 157.

This splendid medusa, one of our most beautiful eucopids, has a bell-shaped umbrella about as high as broad. Size in maturity about 50 to 60 mm. Body of bell rather thick and heavy, particularly in aboral region. Marginal tentacles numerous, with bulbous bases. Manubrium long, capable of protrusion beyond the velum, though usually about on a level therewith. Radial canals 4, rather wide, with gonads extending the entire length and downward upon the elongated peduncle of the manubrium. Mouth with 4 fimbriated eversible lobes. Otocysts numerous and symmetrically distributed about the margin, each containing several otoliths.

Fewkes has called attention (Bulletin Museum Comparative Zoology, Vol. VIII, p. 157) to the fact that specimens are often devoid of the gastric and oral portions of the manubrium. I have frequently noted the same thing, and have suspected that it might be due to voracious fishes, some of which are known to feed upon the oral lobes, etc., of the Scyphomedusæ. Whatever the cause, it seems to prove of small inconvenience to the medusa, as the organ is soon regenerated.

*Ontogeny.*—The ontogeny of *Tima* has been traced by A. Agassiz (cf. North American Acalephæ, p. 115), who has reared the hydroid from the eggs discharged by the medusæ in aquaria. The characteristic phases of development, through planulæ to polyps and hydroid colonies, occupied some six months, at the end of which the colonies were very minute tufts, barely visible to the naked eye.

*Colors.*—While the bell is quite transparent, the milk-white gonads and mouth lobes render the medusa very conspicuous. The tentacles also are white, with a delicate rosy pink in many specimens.

*Distribution.*—Rather general throughout the region—Cape Cod, Vineyard Sound, Woods Hole, Buzzards Bay, Newport, etc. I have taken the species only during early spring—April and May. It has been reported by Agassiz in March, June, October, and December. Facts seem to indicate the sexual season as rather distinctively spring.

### **OBELIA Peron & Lesueur** (1809).

The genus *Obelia*, as at present defined by most authors, is much more comprehensive than was understood by Forbes, McCrady, and Agassiz. As now constituted it comprises medusæ having the following characteristics:

Eight adradial otocysts, which are borne on the inward projecting bases of the marginal tentacles of that region; marginal tentacles numerous, 12 to 24, or even 100 or more. Velum rudimentary, bell flat and freely eversible, the medusæ often swimming more or less freely in that condition.[a]

The extremely variable stage of development at which the medusæ leave the gonothecæ, sometimes with 12, 16, 24, or even 48 tentacles, sometimes with the gonads already well developed, sometimes without any traces of them, render very difficult any certain determination of species; and the same variable tendencies of the hydroid stocks but add to the difficulties of the problem. Hence, in comparatively few cases may we feel even a reasonable assurance that the species usually recognized as distinct are entitled to that rank.

---

[a] As will be noted, this definition includes what by earlier writers were recognized as the genera of *Eucope* and *Obelia*, chiefly.

### **Obelia commissuralis** McCrady.

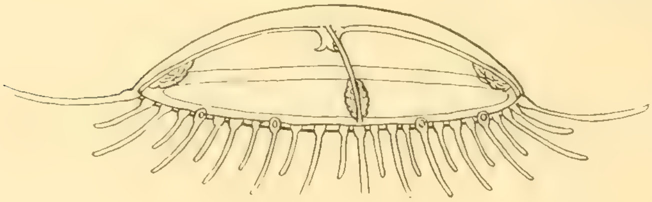
*Laomedia gelatinosa* Stimpson, Marine Invertebrates of Grand Manan, 1853, p. 8, in Smithsonian Contributions to Knowledge, Vol. VI.

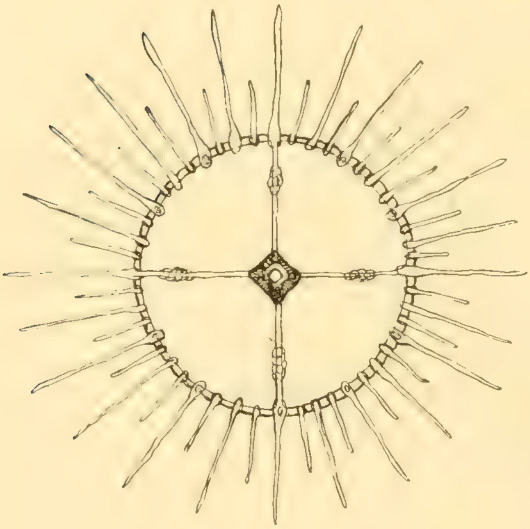
*Laomedia dichotoma* Leidy, Marine Invertebrates of New Jersey and Rhode Island, 1855, p. 6, in Journal Academy Natural Sciences of Philadelphia, Vol. III, 2d series.

*Obelia commissuralis* McCrady, Proceedings Elliott Society of Natural History, Vol. I, 1857, p. 197. L. Agassiz, Contributions to Natural History of United States, Vol. IV, 1862, pp. 315, 351. A. Agassiz, North American Acalephæ, 1865, p. 91, in Bulletin Museum Comparative Zoology, Vol. I. Haeckel, System der Medusen, 1879, p. 174.

Bell flat and discoid; marginal tentacles 16 at liberation; gonads borne on distal half of radial canals; manubrium cylindrical, mouth four-lobed. Size of medusa about 1 mm. at time of liberation. Developed from hydroid of same name.

*Distribution.*—Everywhere throughout the region. Hydroid found on various species of *Fucus*, and very polific, hundreds of medusæ being discharged from a small colony within a few hours at the breeding season.


*Obelia diaphana.*


*Obelia diaphana.* Oral view

### **Obelia diaphana** (L. Agassiz.) Text cuts.

*Thaumantias diaphana* L. Agassiz, Memoirs American Academy of Arts and Sciences, Vol. IV, 1849, p. 300.

*Eucope diaphana* A. Agassiz, in L. Agassiz, Contributions to Natural History of United States, Vol. IV, 1862, p. 322. North American Acalephæ, 1865, p. 83.

*Obelia diaphana* Allman, Annals and Magazine of Natural History, Vol. XIII, 1864, p. 372. Haeckel, System der Medusen, 1879. p. 175.

Medusa flat, discoid, with usually 24 tentacles at liberation, later as many as 200 or more. Size about 1 mm. at birth, becoming as much as 5–6 mm. at maturity. Manubrium cylindrical, with four-lipped mouth, lips short. Gonads usually absent at birth, becoming pyriform at maturity, and borne on distal third of radial canals.

Development as in preceding species, the young sometimes occurring in almost incredible numbers. Hydroid stock very similar to preceding species.

Distribution as of preceding. Common everywhere.

### **Obelia gelatinosa** (Pallas).

*Sertularia gelatinosa* Pallas, Elenchus Zoophytorum, 1766, p. 116.

*Laomedia gelatinosa* Lamarck, Animaux sans Vertebres, Tome II, 1817, p. 134. Lamouroux, Histoire des Polypiers Coralligènes Flexible, 1816, p. 92.

*Laomedia gigantea* A. Agassiz, North American Acalephæ, 1865, p. 94.

*Obelia gelatinosa* Haeckel, System der Medusen, 1879, p. 176.

*Obelia dichotoma* Allman, Annals and Magazine of Natural History, Vol. XIII, 1864, p. 372.

Medusa much as preceding as to general form, tentacles, etc. Tentacles at birth 16 (Hincks), 24 (Haeckel). Manubrium and gonads about as in preceding species. Development from hydroid stock of same name, which, in contrast to those of both the previous species, is very large, attaining a height of a foot or more.

*Distribution.*—Less common than preceding, though taken throughout region.

### **Obelia pyriformis** (A. Agassiz.)

*Eucope pyriformis* A. Agassiz, North American Acalephæ, 1865, p. 88.
*Laomedia pyriformis* Leidy, Marine Invertebrate Fauna New Jersey and Rhode Island, in Journal Academy Sciences, Philadelphia, 1855, p. 6.
*Obelia pyriformis* Haeckel, System der Medusen, 1879, p. 175.

Medusa flat, discoid, with 24 tentacles at birth; gonads also present at this period, pear-shaped and borne on proximal half of radial canals. Otocysts somewhat larger than in some of the preceding species and usually slightly to one side of the tentacular base. Manubrium globular with simple mouth devoid of lobes or lips.

*Development.*—From hydroid of same name, having its habitat chiefly on eel-grass or in similar surroundings.

*Distribution.*—Somewhat general throughout the region.

### **Obelia fusiformis** (A. Agassiz.)

*Eucope* (?) *fusiformis* A. Agassiz, North American Acalephæ, 1865, p. 90.
*Eucope* (?) *divaricata* A. Agassiz, op. cit. p. 91.
*Obelia fusiformis* Haeckel, System der Medusen, 1879, p. 177.

Medusa very similar to former species, but with 48 tentacles at birth, when also the gonads are well developed and of fusiform shape along the length of the radial canals. Manubrium quadrate in shape, with four-lipped mouth.

*Development.*—From hydroid of same name.

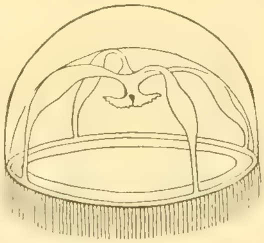
*Distribution.*—Massachusetts Bay, Nahant (Agassiz). I have not identified this medusa from the Woods Hole region, and there may be a question as to its specific distinctness, since Agassiz has himself expressed doubt on this point.

## **TIAROPSIS** L. Agassiz (1849).

### **Tiaropsis diademata** L. Agassiz. Text cut.

*Tiaropsis diademata* L. Agassiz, Memoirs American Academy Arts and Sciences, Vol. IV, 1849, p. 289. Contributions Natural History United States, Vol. IV, 1862, p. 308. A. Agassiz, North American Acalephæ, 1865, p. 69. Haeckel, System der Medusen, 1879, p. 188.

Bell hemispherical, or low dome-like, about half as high as broad. Marginal tentacles very numerous in maturity, though comparatively few when the medusa is liberated. They are always short, forming a delicate fringe upon the margin of the bell. Pigment spots occur at the bulbous bases of the tentacles, and are probably ocellar in character. Eight otocysts are present, distributed between the tentacles, 2 in each quadrant and between the radial canals, each containing black otoliths. The velum is narrow and very delicate. Gonads spindle-shaped, disposed beneath the median radial canal region. Manubrium very short, with four fimbriated oral lobes. Ontogeny unknown.



*Tiaropsis diademata.* After A. Agassiz.

*Colors.*—Bell pale bluish milky tint, gonads darker.

*Distribution.*—Massachusetts Bay, Boston Harbor; occasionally taken at Woods Hole, March to May.

## **OCEANIA** Peron & Lesueur (1809.)

*Oceania* as a generic term has been largely superseded by most European writers upon Hydromedusæ, and Haeckel has designated it as obsolete, merging the medusæ formerly classed under it into other genera, as *Epenthesis*, or instituting new genera which better define the characters of those forms. Several American authors have likewise abandoned the use of *Oceania* as a generic name, but still others, notably A. Agassiz and Mayer, have continued to use it in something of its earlier sense. To the present author it has seemed expedient to continue to use it, though recognizing its growing obsolescence. As at present defined by Agassiz and Mayer, it would seem to differ from *Epenthesis* chiefly in the presence of two octocysts between each two marginal tentacles, and in its larger number of the latter.

### **Oceania languida** A. Agassiz. Pl. V, fig. 2.

*Oceania languida* A. Agassiz, in L. Agassiz, Contributions to Natural History of United States, Vol. IV, 1862, p. 353; North American Acalephæ, 1865, p. 70.
*Phialidium languidum* Haeckel, System der Medusen, 1879, p. 188.

Bell rather low, symmetrically arched, walls very thin and delicate, collapsing when taken from the water. Velum also very narrow and delicate. Marginal tentacles numerous in adult, usually 32 or more, with about 2 otocysts between the bases of each two. Gonads elongate masses along the distal half of the radial canals, or when fully mature extending almost to the manubrium, the latter very short and with four-lobed mouth. Tentacular bulbs large and oval in form. The medusæ are sluggish in temperament, moving languidly, often simply drifting; when disturbed, or even without apparent disturbance, they often contract the margins of the bell, folding the body into an aspect of collapse. This species is very abundant in the Woods Hole region, particularly in middle or late summer. In size it varies from 15 to 20 mm. in broad diameter, with about half the height.

The ontogeny of this medusa is somewhat doubtful. Haeckel assigns it to *Campanulina languida.* I have never been able to determine definitely its entire life history.

*Colors.*—Bell very transparent; tentacle bulbs brownish with green center; gonads likewise greenish brown; manubrium streaked with greenish.

*Distribution.*—Rather general throughout the region, June to September.

### **Oceania singularis** Mayer.

*Oceania singularis* Mayer, Bulletin Museum Comparative Zoology, Vol. XXXVII, 1900, p. 7.

Medusa with straight, sloping sides, and with a rather sharply constricted apical region, somewhat lens-shaped. Marginal tentacles 16, with large hollow basal bulbs, the tentacles rather short and abundantly supplied with mematocysts. There are also 16 rudimentary tentacles and 32 otocysts, 2 between the bases of each two rudimentary tentacles, each otocyst with a single otolith. Manubrium rather long, quadrate in form, and with four-lobed mouth. Ontogeny unknown.

*Colors.*—Bases of tentacles greenish, distal portions brownish, gonads of turquoise tinge.

*Distribution.*—Newport, R. I. (Mayer).

## **EPENTHESIS McCrady** (1857).

### **Epenthesis folleata** McCrady. Pl. V, fig. 3.

*Epenthesis folleata* McCrady, Proceedings Elliott Society of Natural History, Vol. I, 1857, p. 191.
*Oceania folleata* L. Agassiz, Contributions to Natural History United States, Vol. IV, 1862, p. 353. A. Agassiz, North American Acalephæ, 1865, p. 70.
*Epenthesis folleata* Haeckel, System der Medusen, 1879, p. 184.

Low, sub-hemispherical bell about two-thirds as high as broad, with firmer walls than in preceding species. Marginal tentacles 16 in mature specimens, with 16 otocysts alternating therewith, tentacles with rather large basal bulbs. Velum rather narrow but fairly firm in texture. Gonads form elliptical masses on the distal half of the radial canals. Manubrium moderately developed, quadrate in shape, mouth with four everted lips. Ontogeny unknown.

*Colors.*—Basal bulbs of tentacles greenish by reflected light, or brownish by transmitted light. Gonads similarly colored, though paler. Manubrium more or less streaked with light green.

*Distribution.*—Common in Vineyard Sound, Woods Hole, etc., from July to September.

## **PHIALIS Haeckel** (1877).

### **Phialis cruciata** (A. Agassiz).

*Halopsis cruciata* A. Agassiz, North American Acalephæ, 1865, p. 102.
*Phialis cruciata* Haeckel, System der Medusen, 1879, p. 181; Prodromus Systemæ Medusarum, 1877.

Bell low hemispherical, somewhat broader than high, about 30 to 40 mm. broad in adults. Marginal tentacles rather numerous, and with interposed cirri. Otocysts 12, three between each two radial canals. Manubrium rather short, with quadrate base, and with four-lobed mouth and everted lips. Gonads linear along the course of the radial canals. Ontogeny unknown.

*Colors.*—Bell light pinkish, as are also the gonads.

*Distribution.*—Nahant, Massachusetts Bay. This medusa has not been taken within the region in question, though likely to occur there.

## Family ÆQUOREIDÆ.

KEY TO THE GENERA.

A. Radial canals 8 or more, often lobed or forked near proximal ends ........ *Halopsis*
B. Radial canals 12, manubrium very short and flat, oral lobes long, simple or crinkled .... *Stomobrachium*
C. Radial canals usually numerous, 16 to 32, sometimes 100 or more.
  1. Manubrium very short or even indistinguishable, with simply a crenulated oral margin........ *Rhegmatodes*
  2. Manubrium well developed, oral lobes plain ..... [illegible]
  3. Manubrium large and with complexly plaited oral lobes........ *Zygodactyla*

### HALOPSIS A. Agassiz (1863).

### Halopsis ocellata A. Agassiz.

*Halopsis ocellata* A. Agassiz, Proceedings Boston Society Natural History, Vol. IX, 1863, p. 219; North American Acalephæ, 1865, p. 99. Haeckel, System der Medusen, p. 217, 1879.

Bell low and evenly arched, 3 or 4 times as broad as high. Tentacles very numerous and capable of great contraction and extension, with numerous alternating cirri. Radial canals 4 in young specimens, increasing from 12 to 20 in adults. Otocysts large and numerous, composed of double rows of otoliths, and symmetrically disposed along the margin of the bell. Manubrium very short, with four-lobed mouth. Gonads form elongate masses along almost the entire length of the canals.

Agassiz has noted the occurrence of double manubria in specimens of this form, particularly where there is an extension of the gastric pouch in one plane of the medusa, attributes this appearance to a tendency to or "beginning of transverse fission." This inference seems to me hardly warranted without clearer evidence of such fission among medusæ. I have occasionally found the same appearance in smaller medusæ, for example, *Oceania languida* and *Gonionemus*, in which so far as I am aware there has never been noted any tendency to fission. G. T. Hargitt has found frequent examples of such double manubria and mouths in individuals undergoing regeneration of excised parts. (Cf. Biological Bulletin, Vol. IV, p. 6 et seq.)

Agassiz has made observations upon the development of this species. (Cf. Proceedings Boston Society Natural History, Vol. IX, p. 219.)

*Distribution.*—Nahant, Mass., Bay (Agassiz). This medusa has not been taken at Woods Hole recently, nor elsewhere in the southern part of the region, so far as known to me.

### STOMOBRACHIUM Brandt (1838).

### Stomobrachium tentaculatum L. Agassiz.

*Stomobrachium tentaculatum* L. Agassiz, Contributions to Natural History of United States, Vol. IV, 1862, p. 361. A. Agassiz, North American Acalephæ, 1866, p. 98. Haeckel, System der Medusen, 1879, p. 224.

Bell low, evenly arched; radial canals 12, gastric portion of manubrium very flat, mouth with 4 rather triangular lobes which are variously frilled or folded. Tentacles very numerous, but short and devoid of any considerable contraction or extension. Gonads linear in form and disposed along the several canals. Ontogeny unknown.

*Colors.*—The medusa is almost wholly devoid of color.

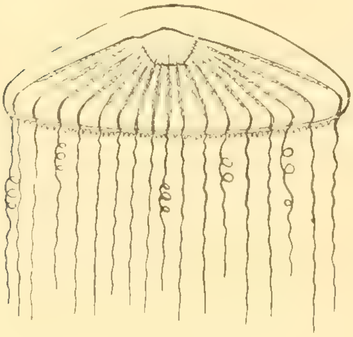
*Distribution.*—Massachusetts Bay (Agassiz). I have occasionally taken at Woods Hole what may have been fragments of the somewhat firm gelatinous portions of this medusa.

### RHEGMATODES A. Agassiz (1862).

### Rhegmatodes tenuis A. Agassiz. Text cut.

*Rhegmatodes* A. Agassiz, in L. Agassiz Contributions to Natural History of United States, Vol. IV, 1862, p. 361
*Rhegmatodes tenuis* A. Agassiz, North American Acalephæ, 1865, p. 95. Haeckel, System der Medusen, p. [illegible] 1879.

Bell very low and flat with evenly rounded exumbrellar surface. Radial canals numerous, from 30 to 40 or more in mature specimens, mostly simple, but exhibiting numerous variations, as spurs, anastomosing branches, etc. Marginal tentacles numerous and evenly disposed, rather filiform and capable of great contraction, during which they are often characteristically coiled, and with a broader base, above which is a tubular, spur-like flap; numerous rudimentary tentacular bodies interposed between the long tentacles. Gonads in double-linear series along the course of the radial canals, extending from slightly beyond the gastric cavity to about the same distance from the marginal canal. Manubrium almost lacking, gastric pouch very flat, mouth a simple crinkled rim about the edge of the gastric pouch. Otocysts numerous and variously interposed between the bases of the tentacles.



*Rhegmatodes tenuis.*

In general habits this medusa is sluggish, swimming languidly by only irregularly intermittent pulsations of the bell margins. The velum is but poorly developed. It varies in size from 25 to 70 mm., the average being about 40 to 50 mm. Ontogeny wholly unknown.

*Distribution.*—Not uncommon throughout the region, but very erratic. During the summer of 1900 it was very abundant at Woods Hole; in 1901 it was entirely absent; in 1902 a very few specimens were taken.

### **ÆQUOREA Peron & Lesueur** (1809).

### **Æquorea albida** A. Agassiz.

*Æquorea albida* A. Agassiz, in L. Agassiz Contributions Natural History of United States, Vol. IV, 1862, p. 359. A. Agassiz, North American Acalephæ, 1865, p. 110. Haeckel, System der Medusen, 1879, p. 221.

Bell somewhat less than hemispherical, tending to conical above. Radial canals very numerous, 80 to 100, or even more. Marginal tentacles, about three between each two adjacent canals, and each with a superposed spur similar to *Rhegmatodes*. Manubrium better developed than in preceding, gastric portion very flat and wide, mouth simple or somewhat crenulated when contracted. Gonads disposed along the entire course of the radial canals. In size this medusa varies about as the preceding species. Ontogeny entirely unknown.

*Distribution.*—Not uncommon in and about Woods Hole during late summer and autumn.

### **ZYGODACTYLA Brandt** (1838).

### **Zygodactyla grœnlandica** (Peron & Lesueur).

*Medusa æquorea*, Fabricius, Fauna grœnlandica, 1780, p. 364.
*Æquorea grœnlandica* Peron & Lesueur, Tableau des Meduses, etc., in Annales du Museum, Vol. XIV, 1809, p. 339.
*Zygodactyla grœnlandica* L. Agassiz, Contributions Natural History of United States, Vol. IV, 1862, p. 360. A. Agassiz, North American Acalephæ, 1865, p. 103.
*Rhacostoma atlantica*, L. Agassiz, Proceedings Boston Society Natural History, Vol. III, 1862, p. 342.
*Polycanna grœnlandica* Haeckel, System der Medusen, 1879, p. 232.

This is one of the largest of the Hydromedusæ, sometimes measuring a foot or more in diameter, and about one-third as high. The bell is rather low and evenly arched above. Radial canals very numerous, 100 or more. Marginal tentacles also numerous, like the preceding species, usually three between each two adjacent canals, and with similar superposed spurs. Manubrium very large, extending beyond the bell margin; gastric portion very broad; oral portion comprising highly complex plaited folds and frills. Gonads in double-linear series along the course of the radial canals. Ontogeny unknown.

*Colors.*—Manubrium, gonads, and tentacles dull whitish.

*Distribution.*—Greenland (Fabricius). Maine to Massachusetts (Agassiz). Occasionally found in Vineyard Sound and Buzzards Bay in late summer and autumn.

## THE TRACHOMEDUSÆ.

PETASIDÆ.—Radial canals 4; manubrium without peduncle, mouth usually simple, occasionally 4 fimbriated lobes; gonads variously folded or undulating, suspended beneath radial canals. Tentacles numerous, usually solid. Otocysts variously distributed between bases of tentacles.

TRACHYNEMIDÆ.—Radial canals 8; manubrium long, devoid of peduncle, with mouth four-lobed. Gonads 8, borne beneath radial canals. Sensory organs, otocysts with central otolith.

AGLAURIDÆ.—Radial canals 8, manubrium long, with short distal bell-shaped stomach, and gelatinous peduncle; mouth usually four-lobed, rarely simple. Gonads usually rather long and cylindrical, borne on radial canals or manubrium. Tentacles always solid. Sensory organs usually free.

GERYONIDÆ.—Radial canals 4 or 6, manubrium long and pendulous, with terminal stomach; peduncle gelatinous, radial canals extending usually the entire length. Gonads usually flat and leaf-like, borne on the subumbrella beneath radial canals. Tentacles of three series: Primary, occurring during young stage, perradially distributed, and solid; secondary, interradially disposed, also solid, and usually disappearing by atrophy; tertiary, the final series, hollow and communicating with the marginal canal. Sensory organs are otocysts, each with a central otolith.

### Family PETASIDÆ.

A single genus under this family comes within this region—namely, *Gonionemus*, which was by Haeckel referred to the cannotid Leptomedusæ (cf. System der Medusen, p. 146). Later and more detailed knowledge both of the structure and life history of *Gonionemus* has clearly demonstrated its trachynemid affinities. While it does not easily come within the current limitations of the Petasidæ, the genus seems most closely related here, and it appears upon the whole better to enlarge the scope of the present family than to establish an additional one.

### GONIONEMUS A. Agassiz (1862).

#### Gonionemus murbachii Mayer. Pl. VI, fig. 1.[a]

*Gonionemus vertens* A. Agassiz, North American Acalephæ, 1865, p. 128; in Contributions Natural History United States, Vol. IV, 1862, p. 350.

*Gonynema vertens* Haeckel, System der Medusen, 1879, p. 147.

*Gonionemus murbachii* Mayer, Bulletin Brooklyn Institute Arts and Sciences, Vol. I, 1901, p. 5.

*Gonionema murbachii*, Yerkes, American Journal of Physiology, Vol. VII, 1902, p. 181. Perkins, Johns Hopkins University Circular, May, 1902.

This species was first described by A. Agassiz in 1862, from the Pacific coast. In 1895 a species was found at Woods Hole and supposedly identified with the Pacific species by Murbach, but it has since been classed as a distinct species by Mayer.

*Gonionemus murbachii* may be characterized as follows: Bell somewhat less than a hemisphere, though in early life, and even in many specimens approaching maturity, it is almost if not quite hemispherical. Manubrium rather short, seldom extending to the velum, quadrangular in shape, with 4 prominent and delicately frilled oral lobes. Radial canals 4, though many specimens are found with 5, 6, or even 2 and 3. (Cf. paper on Variation in Hydromedusæ, by writer, Biol. Bull., Vol. II, 1902.)

Gonads extending under radial canals in undulating folds. Tentacles numerous, 50 to 80 or more in fully developed specimens, and with prominent basal bulbs of brownish color delicately tinged with bright green. Each tentacle with a prominent suctorial pad near the tip, at which point the tentacle often presents a sharp knee-like angle. Sensory bodies, or otocysts, each with a central otolith, variously distributed between the bases of the tentacles.

*Ontogeny.*—The life history and development of this medusa has recently been worked out with much care by H. F. Perkins, who has thus shown that there is a well-defined, though lowly organized hydroid generation, from which presumably, the medusæ are derived by asexual budding.

*Color.*—Bell transparent, radial canals and gonads yellowish-brown, manubrium brownish.

*Distribution.*—Chiefly in the vicinity of Woods Hole, Vineyard Haven, and adjacent waters.

---

[a] The figure is faulty in some respects, but a better substitute was not available.

*Gonionemus* has afforded some extremely interesting ecological phenomena. Its most congenial habitat seems to be in small protected pools or ponds, such as the Eel Pond at Woods Hole, which has only a narrow connection with the harbor, and being surrounded by dwellings, receives garbage and other wastes which must render its waters more or less foul. Eel grass grows luxuriantly in the shallower portions, and in this the medusæ seem to find favorable conditions for lodgment and at the same time abundant food, such as small crustaceans, fish-fry, etc. Thousands of specimens are taken annually from this pond for use in the laboratory and elsewhere, but without apparently diminishing the numbers. When taken elsewhere, as at Vineyard Haven, the conditions have been very similar. The adaptation of the species to such a habitat has seemed to fit it for aquarium life, which in turn has made possible a most remarkable and varied amount of experimental work on coelenterate physiology, as the abundant literature of the past few years amply attests.

## Family TRACHYNEMIDÆ.

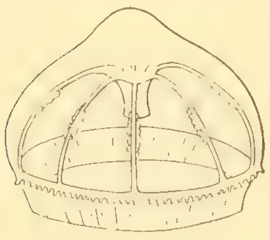
Radial canals 8, simple; no blind centripetal canals; otocysts 16 .............................................. *Rhopalonema*

### RHOPALONEMA Gegenbaur (1856).

### Rhopalonema typicum (Maas). Text cut.

*Homœonema typicum* Maas, Memoirs Museum Comparative Zoology, Vol. XXII, 1897, p. 22.
*Rhopalonema typicum* A. Agassiz & Mayer, Memoirs Museum Comparative Zoology, Vol. XXVI, p. 152. Hargitt, Biological Bulletin, Vol. IV, 1902, p. 15.

Bell hemispherical in general shape, with a low, rounded apical projection. Average size about 9 mm. in broad diameter by about 6 mm. in height. Radial canals 8, with the slightly developed gonads borne about the mid-region of their subumbrellar course. Manubrium urn-shaped and with slightly flaring oral margins. Velum well developed and capable of extension outward, a condition often assumed normally. Marginal tentacles were lacking on the specimens taken, though a fairly regular series of basal fragments indicated about the usual number characteristic of the species. Those of the region adjacent to the radial canals seemed to have been of larger size than the others. No otocysts were distinguishable on the specimens. In view of the solvent action of strong formalin on these bodies in other cases it may not be unlikely that a similar effect resulted in the present case, for this condition prevailed with almost all the specimens of the collection. Ontogeny entirely unknown.



*Rhopalonema typicum.*

*Colors.*—Bell quite transparent, but with an evident irridescence; manubrium dull white, as were also the gonads in the preserved specimens.

*Distribution.*—Region of Gulf Stream, fragments taken in the tow in Vineyard Sound. The occurrence of the species in this comparatively high Atlantic latitude may seem extraordinary, if not improbable, but there do not seem to be sufficient grounds for considering the specimens as distinct from the species here indicated. Maas has described *R. typicum* from the west coast of Mexico (cf. Memoirs Museum Comparative Zoology, Vol. XXII), and Agassiz and Mayer have recently recorded it from the tropical Pacific (cf. op. cit., Vol. XXVI, No. 3).

It should be noted that the specimens taken in Vineyard Sound were all more or less damaged, as already indicated. More perfect specimens and in larger numbers may afford grounds for a different conclusion from that here expressed.

## Family AGLAURIDÆ.

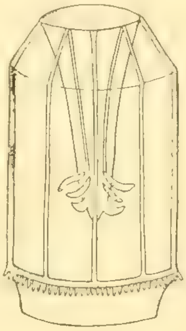
KEY TO THE GENERA.

A. Gonads 8.
    1. Gonads borne on radial canals .... . *Aglantha*
    2. Gonads borne on manubrium ........ *Aglaura*
B. Gonads 4, or sometimes 2.
    3. Gonads 2, on opposite sides of umbrella ........ *Persa*

### **AGLAURA** Peron & Lesueur (1809).

#### **Aglaura hemistoma** Peron & Lesueur. Text cut.

*Aglaura hemistoma* Peron & Lesueur, Tableau des Méduses, 1809, p. 351.
*Aglaura peronii* Leuckart, Archiv für Naturgeschichte, Jahrgaug 22, 1856, p. 10.
*Aglaura hemistoma* var. *nausicaa* Maas, Die Craspedoten Medusen der Plankton-Expedition, 1893, p. 26. Hargitt, Biological Bulletin, Vol. IV, 1902, p. 14.


*Aglaura hemistoma.*

Medusa in form of a cylinder, somewhat octagonal as viewed from either pole. Average size 4 mm. in height by about half as broad. Radial canals 8, extending downward upon the long gelatinous manubrium, which hangs freely in the subumbrellar cavity for about two-thirds its extent. Gastric portion rather short and with prominent four-lobed oral lips. Gonads, 4 or 5 in number, are suspended as finger-like processes from the lower portion of the gelatinous peduncle. Velum well developed and normally having the aspect shown in the figure, though often infolded in similar form within the bell. The tentacles were in nearly every case entirely lacking or so badly distorted as to make impossible any accurate determination of either their number or character; usually, however, the basal portions showed with sufficient clearness to enable a recognition of their presence, and by comparing a number of specimens an approximation as to the number was possible, as shown in the figure. Ontogeny entirely unknown.

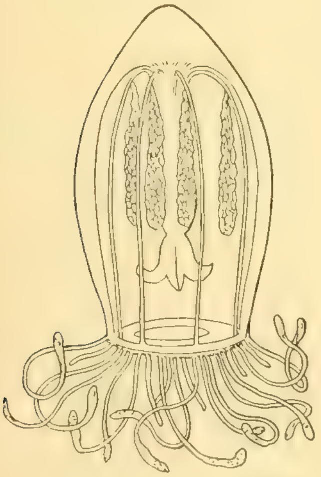
*Colors.*—Bell very transparent; oral portion of the manubrium pale reddish; gonads pale brownish to yellow, or whitish.

*Distribution.*—Region of the Gulf Stream, some 60 miles south of Marthas Vineyard.

### **AGLANTHA** Haeckel (1879).

#### **Aglantha digitalis** (O. F. Muller). Text cut.

*Medusa digitale* O. F. Muller, Prodromus Zoologica Danica, 1766, p. 233. Fabricius, Fauna Groenlandica, 1780, p. 366.
*Melicerta digitale* Peron & Lesueur, Tableau des Meduses, 1809, p. 352.
*Eirene digitale* Eschscholtz, System der Acalephen, 1829, p. 95.
*Circe rosea* Forbes, British Naked-eyed Medusæ, 1848, p. 34. L. Agassiz, Contributions Natural History United States, Vol. IV, 1862, p. 349.
*Trachynema digitale* A. Agassiz, North American Acalephæ, 1865, p. 57.
*Aglantha digitalis* Haeckel, System der Medusen, 1879, p. 272.


*Aglantha digitalis.* After A. Agassiz.

Medusa elongate bell-shaped, with rather sharp apical projection. Radial canals 8, rather wide and extending downward upon the long gelatinous peduncle. Marginal tentacles numerous, but fragile and in many cases detached, apparently by the medusa when brought into captivity. Otocysts 4, with reddish colored otoliths. Gonads 8, suspended like sausages from the upper portion of the radial canals. Velum strong and usually folded within the bell cavity. Gastric portion of the manubrium comparatively small, mouth with four everted lips. The medusa presents different aspects at varying ages, as pointed out by A. Agassiz, the young being shorter and more spherical. Adult specimens 25 to 35 mm. high. Ontogeny entirely unknown.

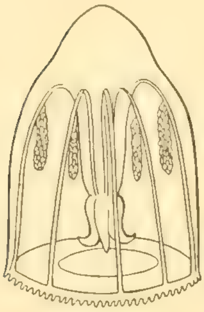
*Colors.*—Bell transparent, slightly pinkish, gonads milky white.

*Distribution.*—Taken at various points within the region, chiefly Woods Hole, March to May. Reported by Agassiz from Massachusetts Bay; by Fabricius from Baffins Bay.

### **Aglantha conica** Hargitt. Text cut.

*Aglantha conica* Hargitt, Biological Bulletin, Vol. IV, 1902, p. 21.

Bell high, with rather sharp apical projection which is slightly constricted at its base in many specimens. Bell walls rather firm, and when compressed tending to wrinkle longitudinally, a condition which often appears also in preserved specimens. Manubrium long and pendulous, though not reaching the velum; peduncle gelatinous; gastric portion much as in the preceding species, as, indeed, are other general characters. Radial canals 8, extending the length of the peduncle. Gonads 8, cylindrical and suspended from the upper portion of the radial canals. Velum well developed and the chief, if not sole, organ of locomotion; movements quick and erratic, the medusæ darting with arrow-like swiftness through the water. Tentacles apparently numerous, but mostly lacking in the specimens taken, notwithstanding the effort to distinguish them on living specimens. Those present rather short and blunt. No marginal organs (otocysts) distinguished even in living specimens.



*Aglantha conica.*

In many respects the specimens resemble very much the preceding species and were at first taken for the young. A comparison as to size and sexual maturity, however, seems to show undoubted specific distinctness as elsewhere pointed out. Average size from 5 to 6 mm. high by about half as wide. Ontogeny entirely unknown.

*Colors.*—Bell very transparent, with only the slighest irridescence by reflected light

*Distribution.*—Taken chiefly off Nantucket; in fewer numbers at another time off Chatham, Mass. Collections were made with the open net at depths of from 12 to 20 fathoms. August.

## Family GERYONIDÆ.

### KEY TO THE GENERA.

1. Three centripetal canals between each pair of radials .......... *Liriope*
2. One centripetal canal between each pair of radials .......... *Glossocodon*

### **LIRIOPE** Lesson (1843).

### **Liriope scutigera** McCrady.

*Liriope scutigera* McCrady, Proceedings Elliott Society of Natural History, Vol. I, 1857, p. 208.
*Liriantha scutigera* Haeckel, System der Medusen, 1879, p. 287.

Bell hemispherical, with thick walls. Radial canals narrow, 4 in number. Manubrium very long, extending far beyond the margin; mouth simple, devoid of lobes; lips small, fringed with nematocysts, short gastrostyle protruding from the mouth. Tentacles long, hollow, very flexible, and with nematocysts arranged in definite rings. Otocysts 4, each with a club-shaped organ. Gonads flat and spindle-shaped in outline, disposed beneath the radial canals. Ontogeny unknown.

*Distribution.*—Newport, R. I. (Fewkes).

### **Liriope cerasiformis** Lesson. Pl. V, fig. 4.

*Liriope cerasiformis* Lesson, Histoire Naturelle Zoophytes Acalephes, 1843, p. 332. Haeckel, System der Medusen, 1879, p. 289. Maas, Craspedoten Medusen der Plankton-Expedition, 1893, p. 35. Hargitt, Biological Bulletin, Vol. IV, 1902, p. 16.
*Liriope exigua* (et *cerasiformis*) Haeckel, Familie der Geryoniden, 1864, p. 24.

Bell subhemispherical, with firm, rather thick walls; size averaging about 10 mm. broad by slightly more than half as high. Radial canals 4, quite distinct, centripetal canals 12, 3 between each two radials. The centripetal canals are only evident upon very critical examination, and this may account for their absence from the earlier accounts of McCrady and the later one by Fewkes, from which a part of the description of the preceding species is condensed. The central of these canals is rather long and narrow with rounded apex, the lateral ones are about half as long and of similar shape. The marginal canal is wide, and communicates freely with both the radial and centripetal canals.

Marginal tentacles 4 on adult specimens; younger specimens often with well-developed interradial tentacles, the gradual disappearance of which is easily traceable in a series of specimens of increasing ages. Nematocysts of tentacles disposed in regular annulations with intermediate perfectly smooth spaces. Manubrium long, extending far beyond the velum; gastric portion rather short and bell-shaped, with slightly quadrate oral lips, beyond which protrudes the pointed gastrostyle. Gonads flat and heart-shaped, and disposed about midway beneath the radial canals. Ontogeny wholly unknown.

*Colors.*—Bell quite transparent, gonads and manubrium dull whitish in formalin specimens.

*Distribution.*—Region of the Gulf Stream, taken in surface tow.

### **GLOSSOCODON** Haeckel (1864).

### **Glossocodon tenuirostris** (L. Agassiz). Text cut.

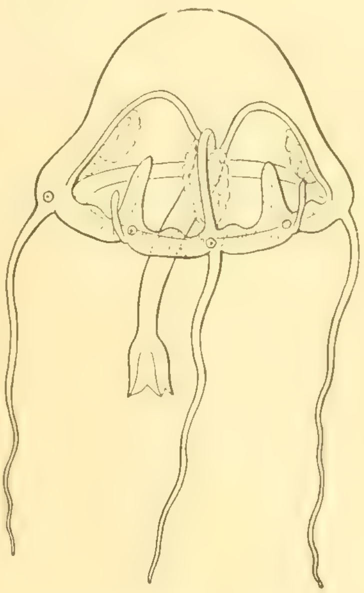
*Liriope tenuirostris* L. Agassiz, Contributions to Natural History of United States, Vol. IV, 1862, 365.

*Glossocodon tenuirostris* Fewkes, Bulletin Museum Comparative Zoology, Vol. IX, 1882, p. 278. Mayer, Bulletin Museum Comparative Zoology, Vol. XXXVII, 1900, p. 165.

Bell somewhat similar to *L. scutigera*, but more globular; also single broad centripetal canals alternating with the 4 radial canals, which are themselves rather wide and prominent. The marginal tentacles present the same aspects of modification as to number, etc., as in *Liriope cerasiformis*, only the 4 perradial being permanent in the adult medusa. Manubrium very long and pendulous, extending far beyond the bell margin; mouth 4-lipped, fringed with nematocysts.

*Colors.*—Bell transparent, gastric portion of manubrium reddish.

*Distribution.*—Chiefly in subtropical waters; reported by Mayer as occasionally taken at Newport. I have not seen this species, the above description being abridged from that of Fewkes.



*Glossocodon tenuirostris.* After Mayer.

## THE NARCOMEDUSÆ.

So far as I am aware, only two, or at most three, families of this order are represented in this region, and these by very few species. Diagnostic characters of the families are given below, but no keys to the genera will be necessary as in families of larger numbers.

## Family CUNANTHIDÆ.

Wide, pouch-like radial canals, which connect by double peronial canals with the marginal canal. Otoporpæ on the bases of the sensory bodies.

### **CUNINA** Eschscholtz (1829).

### **Cunina discoides** Fewkes.

*Cunina discoides* Fewkes, Bulletin Museum Comparative Zoology, Vol. VIII, 1881, p. 161.

Medusa flat, lens-shaped, transparent, with smooth exumbrella. Tentacles 14, stiff, solid, and usually carried at right angles to the vertical line of bell. Manubrium very small or wanting. Otocysts located on the lower margin of the collar-like structure called by Fewkes the subumbrella.

*Distribution.*—Occasionally found at Newport. This account is condensed from Fewkes's description, the medusa being unknown to me.

### Family PEGANTHIDÆ.

No radial canals or gastric pouches, but peronial canal present. Otoporpæ as in preceding.

### Family ÆGINIDÆ.

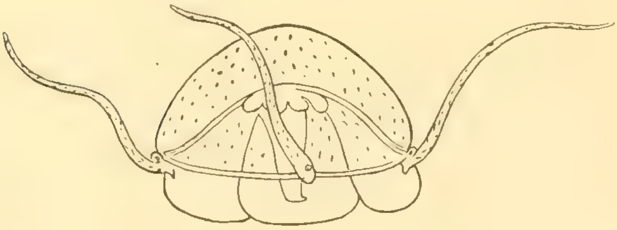
Double peronial canals connecting the gastric pouch with the marginal canal. Interradial pouches present. Otoporpæ lacking.

#### **ÆGINA Eschscholtz** (1829).

**Ægina pachyderma** (A. Agassiz). Text cut.

*Campanella pachyderma* A. Agassiz, North American Acalephæ, 1865, p. 52.
*Ægina pachyderma* Haeckel, System der Medusen, 1879, p. 339.

Bell somewhat conical, slightly broader than high, 1.5 mm. by 1 mm. Marginal tentacles 4, rather long and arched, with numerous clusters of nematocysts, and with ocellate spots on the bulbous base of each. Manubrium well developed, conical in shape, and with plain mouth, genital pouches 8, symmetrically disposed about the manubrium base. Radial and marginal canals well defined.



*Ægina pachyderma.* After A. Agassiz.

*Color.*—Bell dull yellowish, with darker spots scattered over the surface; tentacle basis brownish red.

*Distribution.*—Nahant, September (Agassiz).

I have not seen this medusa, the above description being compiled from that of Agassiz.

### Family SOLMARIDÆ.

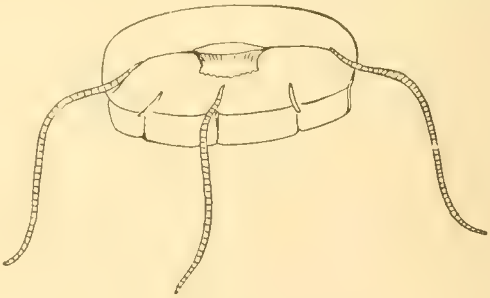
No marginal or peronial canals; sometimes radial canals or modified radial canals. Otoporpæ absent.

#### **SOLMARIS Haeckel** (1879).

**Solmaris tetranema** Hargitt. Text cut.

*Solmaris* Haeckel, System der Medusen, 1879, p. 355.
*Solmaris tetranema* Hargitt, Biological Bulletin, Vol. IV, 1902, p. 18.

Bell flat, discoid, about three times broader than high, 9 mm. by 3 mm. Exumbrellar surface convex, of firm consistency, and with a soft, flexible collar region indefinitely marked off from the former. Medusa without circular or peronial canals. Velum fairly developed. Gastric pouches small, and without distinguishable radial canals. No signs of gonads present. Tentacles 4, of similar size and inserted high upon the sides of the bell, terminating proximally in sharp inwardly directed ends; tentacles stiff over proximal half, but attenuate and rather flexible distally, the endodermal cells in this region seeming much less crowded than proximally. Alternating with these primary tentacles were what appeared to be 4 undeveloped or rudimentary tentacles. At first these were thought to be associated with sensory bodies, but the absence of otocysts or similar structure seems to indicate their tentacular nature.



*Solmaris tetranema.*

A single specimen was obtained near the Gulf Stream and had the appearance of immaturity; being also somewhat damaged, accurate determination was not practicable, yet I have proposed for it the provisional name "*tetranema*," indicative of the number of tentacles.

## SIPHONOPHORA.

Almost, if not all, the members of this order likely to be taken in the Woods Hole region are incidental rather than integral faunal factors, borne hither by tropical currents or prevailing winds from seaward. The proximity of the Gulf Stream and its general course are undoubtedly the most dominant influences in transporting various subtropical faunal elements to these waters.

The following synopsis furnishes hardly more than a convenient check list of species of which I have been able to find records, and only a comparatively few of which I have personally taken during the more than ten years of observation and collecting within the region.

The order Siphonophora comprises three fairly distinct suborders or sections.

### Disconectæ.

With discoidal pneumatophore, but devoid of nectophores or bracts.

### **VELELLA** Bosc (1802).

### **Velella mutica** Bosc.

*Velella mutica* Bosc, Histoire Naturelle des Vers, Tome II, 1802, p. 158. L. Agassiz, Contributions Natural History United States, Vol. IV, 1862, p. 366. A. Agassiz, North American Acalephæ, 1865, p. 216.
*Armenista mutica* Haeckel, Siphonophora Challenger Report, Zoology, Vol. XXVIII, 1888, p. 84.
*Velella mutica* Mayer, Bulletin Museum Comparative Zoology, Vol. XXXVII, 1900, p. 71.

Pneumatophore an elliptical or oblong disc, usually with an oblique vertical crest, and with numerous zooids suspended from its lower surface. Color of radial canals and manubrium often brilliant ochraceous. Occasionally taken in Vineyard Sound, Buzzards Bay, and off Newport.

### **PORPITA** Lamarck (1816).

### **Porpita linnæana** Lesson.

*Porpita linnæana* Lesson, Histoire Naturelle des Zoophytes Acalephes, 1843, p. 589. L. Agassiz, Contribution Natural History United States, Vol. IV, 1862, p. 366. A. Agassiz, North American Acalephæ, 1865, p. 218. Mayer, Bulletin Museum Comparative Zoology, Vol. XXXVII, 1900, p. 72.

Pneumatophore a circular disc but devoid of vertical crest, otherwise similar in general aspects to the preceding.

*Distribution.*—Occasionally taken at Woods Hole, Vineyard Sound, Newport, R. I., etc.

### Calyconectæ.

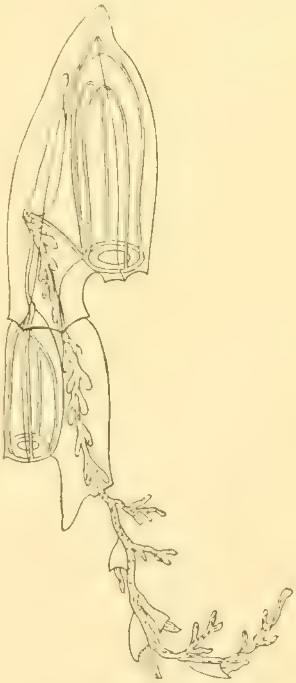
Without pneumatophores, but with one or more nectophores.

### **DIPHYES** Cuvier (1817).

### **Diphyes bipartita** Costa. Text cut.

*Diphyes bipartita* Costa, Genere Diphya, 1840, p. 4.
*Diphyes acuminata* Fewkes, Bulletin Museum Comparative Zoology, Vol. VI, 1880, p. 142.
*Diphyes bipartita* Chun, Siphonophoren der Kanarischen Inseln, 1888; Siphonophoren der Plankton-Expedition, 1897, p. 24. Mayer, Bulletin Museum Comparative Zoology, Vol. XXXVII, 1900, p. 74.

This species is widely distributed throughout the tropical Atlantic and not infrequently drifts into the bays of the region from the Gulf Stream. Mayer records it as often taken at Newport in late summer. Specimens were taken off the borders of the Gulf Stream during 1902. Figure 25, after Mayer, gives a good general impression of the shape of this medusa, but no figure can give the remotest idea of its delicacy or motions.



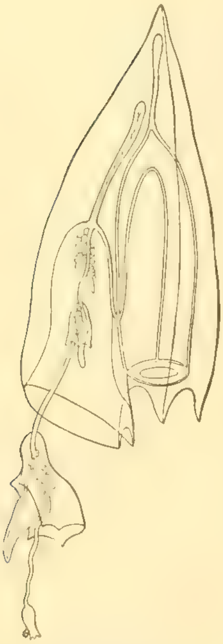
*Diphyes bipartita.* After Mayer.

### DIPHYOPSIS Haeckel (1888).

### Diphyopsis campanulifera Eschscholtz. Text cut.

*Diphyes campanulifera* Eschscholtz, System der Acalephen, 1829, p. 137.
*Diphyopsis campanulifera* Chun, Die Siphonophoren der Kanarischen Inseln, 1888; Die Siphonophoren der Plankton-Expedition, 1897, p. 26. Mayer, Bulletin Museum Comparative Zoology, Vol. XXXVII, 1900, p. 75.

This form is similar in general characters and distribution to the preceding. The accompanying figure, after Mayer, gives an idea of its general shape and size. Chun regards it as an extremely variable species, both in the size and proportions of the colony. It is frequently taken in the deeper tows, particularly south of Marthas Vineyard and in the region of Nantucket.



*Diphyopsis campanulifera.*
After Mayer.

### CUPULITA Quoy & Gaimard (1827).

### Cupulita cara (A. Agassiz).

*Nanomia cara* A. Agassiz, North American Acalephæ, 1865, p. 200.
*Agalma elegans* Fewkes, (?) Report U. S. Fish Commission 1884, p. 964, 1886.
*Cupulita cara* Chun, Die Siphonophoren der Plankton Expedition, 1897, p. 103.

This is a large siphonophore, of a generally boreal habitat. The description of Agassiz (vide supra) is quite full, with good figures, including also accounts of its development, which obviates the necessity of fuller details here.

### HIPPOPODIUS Quoy & Gaimard (1827).

### Hippopodius luteus Quoy & Gaimard.

*Hippopodius luteus* Quoy & Gaimard, in Annales des Sciences Naturelles, Tome X, 1827, p. 172.
*Gleba hippopus* Fewkes, Report U. S. Fish Commission 1884, 1886, p. 963.
*Hippopodius luteus* Chun, Die Siphonophoren der Plankton-Expedition, 1897, p. 34.

Occasionally taken within the region adjacent to the Gulf Stream, but rarely, if at all, near to the coast.

### ANTHOPHYSA Mertens (1829).

### Anthophysa formosa (Fewkes).

*Athorybia formosa* Fewkes, Bulletin Museum Comparative Zoology, Vol. IX, 1882, p. 271.
*Anthophysa formosa* Chun, Die Siphonophoren der Plankton-Expedition, 1898, p. 61.

This species was first described by Fewkes from the Tortugas, and has not since been recorded out of that general region till reported by Chun (vide supra). Hæckel has described under the name of *Anthophysa darwinii* what is apparently the same species.

During the summer of 1902 a single specimen of this interesting siphonophore was taken south of Marthas Vineyard. It agrees in general characters with the descriptions of both Fewkes and Chun. In size it is intermediate between the specimens they described, being about 4 mm. in diameter, and about the same in height.

### SPHÆRONECTES Huxley (1859).

#### Sphæronectes gracilis (Claus). Text cut.

*Monophyes gracilis* Claus, Schriften Zoologischer Institut Wien, 1874, p. 29.
*Diplophysa inermis* Fewkes, Bulletin Museum Comparative Zoology, Vol. VI, 1881, p. 143.

The figure given herewith will afford a generally sufficient means of identification. Fewkes reports the species from Newport, R. I. Other than this I am not aware that it has been found within this region.

### CYSTONECTÆ.

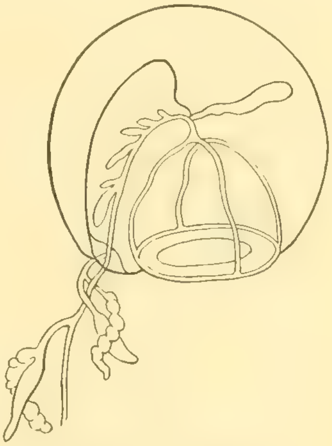
With large vesicular pneumatophore only, no nectophores or bracts.

### PHYSALIA Lamarck (1801).

#### Physalia pelagica Bosc.

*Physalia pelagica* Bosc, Histoire Naturelle des Vers, Tome II, p. 168, 1802.
*Physalia arethusa* Tilesius, in Krusenterns Reise, 1812, p. 91.
*Physalia caravella* Eschscholtz, System der Acalephen, 1829, p. 160.
*Physalia pelagica* Lamarck, Animaux sans Vertèbres, 2d edition, 1840, p. 92. Huxley, Oceanic Hydrozoa, 1859, p. 100.
*Physalia arethusa* L. Agassiz, Contributions to Natural History of the United States, 1862, p. 335. Chun, Die Siphonophoren der Plankton-Expedition, 1897, p. 89.

This is, for several reasons, the best known of siphonophores. Its large size and conspicuous float, and long and numerous tentacles with their powerful batteries of nematocysts, have combined to render the species noteworthy. These alone are generally sufficient for its easy identification. The large and beautifully colored pneumatophore, capable of nice adjustments to wind and wave, the graceful and pendulus tentacles, the languid, passively floating habit of the creature, and last, if not least, its venomous repute, render its presence a center of eager interest to observers. It is a fairly familiar object in Vineyard Sound and adjacent waters, at times as many as fifty specimens being taken during a single cruise within a few miles of Woods Hole.


*Sphæronectes gracilis.* After Mayer.

## THE SCYPHOMEDUSÆ.

In general form, structure, habits, and distribution the Scyphomedusæ have much in common with the Hydromedusæ and probably sustain a much closer relation to them than to any other of the cœlenterate classes. As a rule they are of larger size, somewhat sluggish in habits, the margin of the umbrella is more or less evidently lobed, and there is usually a large manubrium which is provided with large oral lobes, often complexly fimbriated or plaited. The body is also usually much thicker and more rigid than in the Hydromedusæ, and in some of the orders it is provided with a well-organized muscular system.

As in the Hydromedusæ there is usually a well-defined alternation of generations, though with notable exceptions in some of the orders, and in all there seems to be a tendency toward the suppression of the nonsexual stage, which is frequently quite inconspicuous and more or less temporary. In contrast with this phase in the Hydromedusæ, the metamorphism is usually more extended and arises differently—namely, by a process of transverse fission, known as strobilization, the entire body of the polyp constricting into a series of segments which eventually become free larval jelly-fishes known as ephyræ. These in turn pass by an insensible metamorphism directly into medusæ. Direct asexual budding from the adult medusæ is very rare in this class, though quite common in the former. Here the medusa seems the predominant phase in the life history, while quite the reverse is frequently the case with the Hydromedusæ, where the hydroid is often large, long lived, and conspicuous, the medusa small, rudimentary, or entirely suppressed.

The following morphological characters are usually sufficient for the distinction of the two classes:

1. Absence of a true velum. The velarium of the Cubomedusæ has important structural differences, though doubtless serving essentially similar functions.
2. The sexual organs and products of entodermic origin.
3. Gastric filaments usually distinct.
4. Sense organs, when present, are perhaps modified tentacles, known as tentaculocysts, or rhopalia.

There are four clearly distinguishable orders of Scyphomedusæ, characterized as follows:

I. Stauromedusæ.—Vasiform or subconical umbrella. The medusa sedentary in some cases, attached by an aboral peduncle or stalk. Wholly devoid of sensory organs, but provided with 8 tentacles or tentacular organs which serve as anchors. Stomach with 4 wide gastric pouches, which communicate with a marginal canal. Gonads in four crescentic loops on the floor of the gastric pouches.

II. Peromedusæ.—Umbrella more or less conical in shape and with usually a well-developed horizontal constriction which divides the body into two regions—an aboral, which often resembles very much the apical projection of many Hydromedusæ; and a basal or marginal portion, which is 8 or 16 lobed and bears tentacles and rhopalia. Stomach capacious, with 4 gastric pouches which are separated by narrow septa and extend into a circular sinus. Gonads much as in the former order.

III. Cubomedusæ.—A distinctively quadrate body or umbrella, which is provided with a definite velarium supported at the radial angles by thickenings or frenulæ. Marginal tentacles 4, interradially disposed, their bases often provided with wing-like expansions known as pedalia; rhopalia 4, perradially disposed.

IV. Discomedusæ.—A shallow, or disk-shaped, eight-lobed umbrella. Marginal sense organs 8, per- and interradially disposed about the margin. Tentacles often very numerous. Manubrium frequently large and with pendulous oral lobes variously plaited or crenulated. Stomach usually large, with 4 to 8 or more gastric pouches, within which the sexual organs are borne in gastrogenital pockets.

The medusæ of this order are often of large size, many specimens of *Cyanea* reaching a diameter of 3 to 4 or even 6 feet and having tentacles of 50 to 60 feet or more in length when fully extended. The average size, however, even in this genus, is generally much smaller.

By far the greater number of Scyphomedusæ are members of this order, as will be seen in the following list of genera and species found within the region under discussion; and this is true of other regions as well.

## STAUROMEDUSÆ.

Tessaridæ.—Margin of umbrella devoid of lobes or anchors, apex attenuated into a hollow stalk, which in certain genera serves as a means of attachment; tentacles 8, 4 of which are perradial and 4 interradial.

So far as known to me, no representatives of this family come within this region.

Lucernariidæ.—Margin of umbrella definitely lobed, each lobe terminating in a tuft of delicate, knobbed tentacles. Exumbrella attenuated at the apex as an organ of attachment; margin of umbrella with 8 tentacles, arranged as in the preceding family, but in some cases modified as anchors.

## Family LUCERNARIIDÆ.

KEY TO THE GENERA.

A.—Without gastrogenital pockets in the subumbrellar wall of the radial pouches.
  1. Umbrella with 8 marginal anchors.......... *Haliclystus*
  2. Umbrella without marginal anchors.......... *Lucernaria*
B.—With 4 perradial gastrogenital pockets in the subumbrellar wall of the 4 radial pouches
  3. Margin of umbrella with 8 anchors.......... *Halicyathus*

### **HALICLYSTUS** Clark (1863).

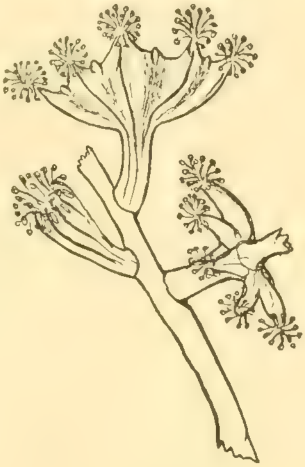
#### **Haliclystus auricula** Clark. Text cut.

*Haliclystus auricula* Clark, Journal Boston Society Natural History, Vol. VII, 1863, p. 559; A. Agassiz, North American Acalephæ, 1865, p. 63; Lucernariæ and Their Allies, 1878, p. 13, in Smithsonian Contributions to Knowledge, Vol. XXIII. Haeckel, System der Medusen, 1879, p. 389.
*Haliclystus primula* Haeckel, Prodromus Systemæ Medusarum, 1877, No. 375.

Umbrella octangular to pyramidal, stalk quadrate, approximately as long as the bell height; 8 arms, arranged in pairs; 4 perradial sinuses, broader and deeper than the 4 interradials, each arm with from 100 to 120 tentacles; 8 large marginal anchors. Size, broad diameter, 20–30 mm.; height, including stalk, about the same.

*Colors.*—Variable, often including every tint of the spectrum. Usually, however, the color is simple.

*Distribution.*—Massachusetts Bay northward.



*Haliclystus auricula.* After A. Agassiz.

#### **Haliclystus salpinx** Clark (1863).

*Haliclystus salpinx* Clark, Journal Boston Society Natural History, Vol. VII, 1863, p. 563. A. Agassiz, North American Acalephæ, 1865, p. 64. Haeckel, System der Medusen, 1879, p. 388.

Umbrella octangular, stem quadrate to prismatic and provided with 4 interradial longitudinal muscles. Eight arms symmetrically disposed, each with a tuft of 60–70 tentacles. Marginal anchors very large and about as long as the tentacles.

*Distribution.*—Chiefly northeastern Atlantic coast.

### **LUCERNARIA** O. F. **Muller** (1776).

#### **Lucernaria quadricornis** O. F. Muller.

*Lucernaria quadricornis* O. F. Muller, Prodromus Zoologia Danica, 1776. M. Sars, Fauna Littoralis Norvegiæ, 1846. L. Agassiz, Contributions Natural History United States, Vol. IV, p. 175, 1862. Clark, Journal Boston Society Natural History, Vol. VII, 1863, p. 552. A. Agassiz, North American Acalephæ, p. 62, 1865. Haeckel, System der Medusen, 1879, p. 390.

Umbrella flat funnel-shaped to quadrate pyramidal, about twice as broad as high. Stalk cylindrical, single-chambered, about as long as the bell height and with 4 interradial longitudinal muscles. Eight arms, arranged in pairs; the 4 perradial sinuses of the bell margin as broad and deep as the 4 interradials; each arm with 100 or more tentacles. Diameter of umbrella about 50 mm.; height, including stock, slightly greater.

*Colors.*—Variable, gray, green, yellowish-brown to reddish.

*Distribution.*—About as for *Haliclystus*.

### **HALICYATHUS** Haeckel (1879).

### **Halicyathus lagena** Haeckel.

*Lucernaria auricula* Fabricius, Fauna groenlandica, 1780, p. 341.
*Lucernaria fabricii* L. Agassiz, Contributions to Natural History of United States, Vol. IV, 1862, p. 176.
*Manania auricula* Clark, Journal Boston Society Natural History, Vol. VII, 1863, p. 542; A. Agassiz, North American Acalephae, 1865, p. 62.
*Manania lagena* Haeckel, Prodromus Systemae Medusarum, 1877, No. 381.
*Halicyathus lagena* Haeckel, System der Medusen, 1879, p. 394.

Umbrella deep, flask-shaped, about twice as high as broad; stalk slender, cylindrical, single-chambered, much longer than height of bell. Arms 8, arranged in pairs, not longer than broad, each with 60 to 70 delicate tentacles. Eight marginal anchors. Diameter 5 to 7 mm.; height, including stalk, 20 to 30 mm.

*Colors.*—Black to dark brown, occasionally reddish.

*Distribution.*—Eastport, Me. (Stimpson); Swampscott, Mass. (Agassiz).

These four descriptions are compiled chiefly from those of Agassiz, Haeckel, Stimpson, and Clark. The species are only rarely found within the Woods Hole region.

## PEROMEDUSÆ.

Only a single genus of the Peromedusæ is known to come within the limits of this region, and that but rarely, specimens being drifted in currents of the Gulf Stream.

*Generic characters.*—Umbrella with 4 perradial, buccal pouches and with 4 basal funnels; gastric pouches with 2 rows of filaments.

### **PERIPHYLLA** Steenstrup (1837).

### **Periphylla hyacinthina** Steenstrup.

*Periphylla hyacinthina* Steenstrup, Acta Musei Hafniensis, 1837. Haeckel, Systemae der Medusen, 1879, p. 419. Fewkes Report U. S. Fish Commission 1884, p. 933.

Umbrella bell-shaped; the 8 tentacle lobes with about the same marginal dimensions as the rhopalial lobes. Length of tentacles about twice the bell-height. Manubrium extending to base of the marginal lobes, and about twice as broad as long.

*Colors.*—Exumbrella reddish, pedalia and marginal lobes red to violet, tentacles bluish (Haeckel).

*Distribution.*—Greenland (Steenstrup); Gulf Stream south off Marthas Vineyard (Fewkes).

### **Periphylla humilis** Fewkes.

*Periphylla humilis* Fewkes, Report U. S. Fish Commission 1884, p. 931.

Umbrella low, conical, diameter twice that of height. Rhopalia 4, provided with protecting hoods. Marginal tentacles 12, yellowish in color. Exumbrella brown, rough and opaque; central disk and corona usually uniform brownish.

*Distribution.*—As of preceding species.

### **Periphylla peronii** Haeckel.

*Charybdea periphylla* L. Agassiz, Contributions Natural History United States, Vol. IV, 1862, p. 173. Peron and Lesueur, Tableau des Meduses, 1809, p. 332. Verrill, Report U. S. Fish Commission 1871, p. 724.
*Periphylla peronii* Haeckel, System der Medusen, 1879, p. 420.

Umbrella low-conical, about as broad as high. Marginal lappets 16, 8 tentacular and 8 ocular. Tentacles long and stout, about as broad at base as the marginal lappets. Manubrium about as broad as long, and somewhat cubical in shape.

*Distribution.*—Tropical Atlantic (L. Agassiz); Georges Bank (S. I. Smith).

## CUBOMEDUSÆ.

Of the Cubomedusæ only a single family has representatives in this region, so far as I am aware, and of this but a single genus and species occurs. Other examples are likely to occur, however, under favorable circumstances.

### CHARYBDEA Peron & Lesueur (1809).

### Charybdea verrucosa Hargitt. Pl. V, fig. 5[a].

*Charybdea verrucosa* Hargitt, American Naturalist, Vol. XXXVI, July, 1902, p. 559.

Several specimens of this species were taken by the author at Woods Hole in the summer of 1901 and were briefly described (vide supra). The following are distinctive characters:

Bell ovoid in outline as seen in profile, cuboid as viewed from either pole. Size 4–5 mm. in height by 2–3 mm. in width. Surface of bell dotted somewhat irregularly with light brownish, warty clusters of nematocysts. Rhopalia 4, perradially located and set in rather deep pockets arched by protecting hoods. Tentacles 4, interradial, spindle-shaped, and deeply annulated. Velarium well developed, but devoid of any distinguishable canals and supported by frenulæ on the inner perradial corners of the subumbrella. Gonads undeveloped in the specimens, which were likewise without distinguishable gastric filaments.

*Colors.*—Light amber-brown, with deeper brown on the tentacles.

As pointed out in the original description, the specimens show many contrasts as compared with to typical species of *Charybdea.* This may be due in part to the immaturity of the specimens, as already suggested. Mayer has described a similar species from the Tortugas which he likewise considers immature, and he makes the same suggestion concerning a somewhat similar form described by Fewkes. This assumption may in a measure account for certain of the negative characters noted, but it has seemed to me doubtful whether it adequately accounts for all. In the absence of specimens in sufficient numbers to warrant a decisive determination, however, the matter must of necessity rest where it is for the present.

Two species described by Mayer from the Tortugas—namely, *Charybdea aurifera* and *C. punctata*—were based on single specimens, which, being regarded as immature, as above mentioned, leaves the same doubt as in reference to *C. verrucosa.* A comparison of Mayer's description and figures (cf. Bul. Mus. Com. Zool., XXXVII, No. 2) will show many points of similarity, though at the same time evident points of difference.

## DISCOMEDUSÆ.

### CANNOSTOMÆ.

Discomedusæ with simple quadrate mouth, devoid of oral lobes or tentacles. Marginal tentacles short, solid.

Ephyridæ.—Radial pouches usually 16, broad and simple; no marginal canal. Chiefly deep-sea forms, though occasionally taken at the surface.

Linergidæ.—Radial pouches broad, terminating in numerous branching, blind distal canals.

### SEMOSTOMÆ.

Discomedusæ with quadrate mouth and with elongated oral arms or lobes which are often complexly folded and frilled. Marginal tentacles hollow, often very long. Marginal lobes of umbrella usually 8.

Ulmaridæ.—Radial canals of small size, but usually numerous and branching, the branches often anastomosing into an intricate network and finally uniting with a definite marginal canal.

Cyaneidæ.—Radial canals broad and pouch-like, and with numerous, blind, lobular canals; no marginal canal. Marginal lobes 8–16, rarely more.

Pelagiidæ.—Radial canals rather broad and pouch-like, but simple and without ramifying branches; no marginal canal. Marginal lobes usually 16.

### RHIZOSTOMÆ.

Discomedusæ in which the mouth early becomes more or less overgrown and obliterated by the 8 root-like oral arms, into which the gastric cavity extends. Openings to the outer surface through various funnel-like mouths on the edges and surfaces. There are no marginal tentacles.

Torumidæ.—Radial canals 8–16, narrow and with anastomosing branches. Marginal canal absent. Rhopalia 8–16. Suctorial funnels on the outer surface of the oral arms.

Pilemidæ.—Radial canals 8–16, occasionally more, variously branching and anastomosing. Rhopalia 8. Suctorial funnels on both inner and outer surfaces of the oral arms.

---

[a] Drawn by H. B. Bigelow.

## Family EPHYRIDÆ.

### KEY TO THE GENERA.

1. Gonads 4, lobular pouches 16, 8 ocular and 8 tentacular .......... *Bathyluca*
2. Gonads 4, simple, horseshoe-shaped; marginal lobes 16–32 .......... *Ephyroides*
3. Gonads 8, symmetrically disposed; lobular pouches 16, ocular .......... *Nausithoe*
4. Gonads 8, symmetrically disposed; lobular pouches 32, 16 ocular, 16 tentacular .......... *Nauphantopsis*
5. Gonads 8, arranged in pairs; lobular pouches numerous .......... *Atolla*

### BATHYLUCA Mayer (1900).

### Bathyluca solaris Mayer.

*Bathyluca solaris* Mayer, Bulletin Museum Comparative Zoology, Vol. XXXVII, 1900, p. 2.

Umbrella rather flat and thick, aboral surface dotted with batteries of nematocysts; marginal lappets 24; tentacles 16, long and hollow; rhopalia 8; manubrium cruciform, simple, devoid of arms or appendages. Gonads 4, horseshoe-shaped; 4 subgenital pits beneath them on the subumbral wall. Stomach large and with 16 gastric pouches, 8 of which extend to the ocular lobes and 8 to the tentacular lobes.

*Colors.*—Disk translucent; slightly bluish; clusters of nematocysts dull yellowish-brown; tentacles slightly greenish.

*Distribution.*—Narragansett Bay, R. I. Condensed from Mayer's description, which is the only record for this region.

### EPHYROIDES Fewkes (1884.)

### Ephyroides rotaformis Fewkes.

*Ephyroides rotaformis* Fewkes, Report U. S. Fish Commission 1884, p. 949.

Fewkes describes what he considers both a new genus and species. The generic characters are not definite, no mention being made as to gonads, radial pouches, etc. The following description is condensed from the report above cited:

Umbrella flat discoid, and viewed from the aboral aspect comprises three zones—"discus centralis," "zona coronalis," "zona marginalis." The last-named zone is marked by definite marginal lappets of large size with rounded outlines twice as long as broad and 16 in number. Interposed between the lappets are a similar number of gelatinous elevations—"socles"—ending a short distance from the deepest point of the marginal incision of the discus centralis and zona coronalis. The marginal lappets are supported at their base by a pair of gelatinous socles.

### NAUSITHOE Kölliker (1853).

### Nausithoe punctata Kölliker.

*Nausithoe punctata* Kölliker, Zeitschrift fur Wissenschäftliche Zoologie, Vol. IV, 1853, p. 323. L. Agassiz, Contributions Natural History United States, Vol. IV, 1862, pp. 122, 167. Mayer, Bulletin Museum Comparative Zoology, Vol. XXXVII, 1900, p. 67.

Reported by Mayer from the Bahamas and Tortugas, and therefore likely to be found in the Woods Hole region, though not yet recorded there.

### NAUPHANTOPSIS Fewkes (1884).

### Nauphantopsis diomedeæ Fewkes.

*Nauphantopsis diomedeæ* Fewkes, Report U. S. Fish Commission 1884, p. 944–946.

From fragmentary specimens collected by the *Albatross* in the Gulf Stream, Fewkes has described this genus and species as new. The following brief synopsis of characters is taken from the report cited.

Umbrella high disk-shaped, with somewhat vertical walls, as in *Linerges*. Exumbrella divided into a central disk and a peripheral corona by a shallow coronal furrow. Corona crossed by 32 radial furrows alternating with same number of radial rounded elevations. Marginal lappets 32, rectangular in shape with rounded free angles. Tentacles 24, long and flexible, arising from the incision between the marginal lappets. Rhopalia 8 (?).

*Distribution.*—Latitude 38, longitude 69; depth 2,033 fathoms.

### **ATOLLA** Haeckel (1879).

### **Atolla bairdii** Fewkes.

*Atolla bairdii* Fewkes, Report U. S. Fish Commission 1884, p. 936.

Umbrella disk-like, with aboral center convex. Marginal lappets 44, marginal tentacles 22, each supported by a gelatinous "socle." Rhopalia 22, situated in notches between the lappets. Manubrium large, with simple mouth; gastric pouches 22.

*Color.*—Slightly bluish, with rust-colored patches, especially on the border of the coronal furrow.

*Distribution.*—Gulf Stream, latitude 35–38, longitude 72–75.

### **Atolla verrilli** Fewkes.

*Atolla verrilli* Fewkes, Report U. S. Fish Commission 1884, p. 939.

Umbrella flat discoid, 6 to 8 times broader than high. Marginal tentacles 22 to 28, with the same number of interposed rhopalia. Marginal lappets same in number as tentacles and rhopalia combined. The umbrella is divided into two regions, a central disk and a peripheral corona, separated by a coronal furrow. In some specimens the consistency was quite cartilaginous.

*Color.*—A slightly bluish tinge.

*Distribution.*—Gulf Stream, latitude 38–40, longitude 68–71; depth from 373 to 2,369 fathoms.

## Family LINERGIDÆ.

### **LINERGES** Haeckel (1879).

### **Linerges mercurius** Haeckel.

*Linerges mercurius* Haeckel, System der Medusen, 1879, p. 495. Fewkes, Report U. S. Fish Commission 1871, p. 950. Mayer, Bulletin Museum Comparative Zoology, Vol. XXXVII, 1900, p. 68.

Reported as very common in Straits of Florida by Fewkes, and by Mayer as abundant in the Bahamas and Tortugas. Its occurrence within our portion of the Gulf Stream is therefore quite probable, though not yet recorded.

## Family ULMARIDÆ.

KEY TO THE GENERA.

1. Rhopalia 8; tentacles numerous, short, borne on under margin of umbrella outside the velar lappets............*Aurelia*
2. Rhopalia 16; tentacles numerous, long, in 16 clusters on the lower margin within the velar lappets........*Phacellophora*

### **AURELIA** Peron & Lesueur (1809).

### **Aurelia flavidula** Peron & Lesueur. Pl. VI, fig. 2, and text cut.

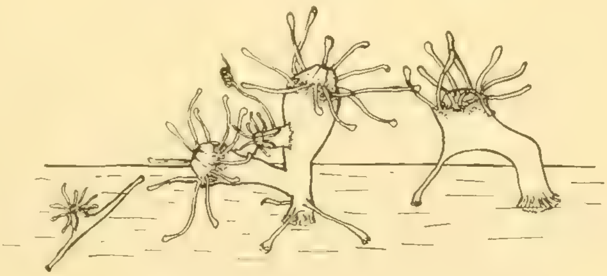
*Aurelia flavidula* Peron & Lesueur, Tableau des Meduses, etc., 1809, p. 359. Lesson, Histoire Naturelle des Zoophytes Acalephes, 1843, p. 376.

*Medusa aurita* Fabricius, Fauna Groenlandica, 1780, p. 363. Gould, Report Invertebrates of Massachusetts, 1841, p. 348.

*Medusa flavidula* Gould, op. cit.

*Aurelia flavidula* L. Agassiz, Contributions Natural History United States, Vol. IV, 1862, pp. 51, 160. A. Agassiz, North American Acalephæ, 1865, p. 42. Haeckel, System der Medusen, 1879, p. 555

Umbrella flat and disk like, somewhat arched above; margin normally 8-lobed and with 8 rhopalia which are symmetrically disposed in the sinuses of marginal lobes. Marginal tentacles numerous, but short, forming a delicate fringe about the entire margin except at the marginal sinuses. Radial canals 16, of three sorts—perradial and interradial, each of these branching and anastomosing freely, and adradial, 8 in number, simple and unbranched, passing directly from the gastric pouches to the marginal canal. Manubrium quadrate, with oral arms about as long as the bell-radius, rather broad and heavy proximally, but terminating in slender pointed crenulated ends; entire margins of arms more or less folded or scalloped and richly supplied with nematocysts. In life the oral arms are carried in an extended position, much as shown in the plate. Gonads



Scyphostomae *of Aurelia flavidula.*

crescent-shaped organs, located upon the floor of the gastric pouches and giving the medusa a distinctive appearance not easily confused with any of the Scyphomedusæ likely to be found within the region.

*Aurelia* exhibits interesting aspects of variability, particularly in the radial canal system, the marginal lobes, rhopalia, and gonads. Browne (1901) has shown this in some detail in *A. aurita*. An examination of several hundred specimens of adult *Aurelia flavidula* shows a very similar condition, a ratio of variation as high as 20 to 25 per cent, and an examination of more than a thousand of the ephyræ of this medusa gives a like result. Details upon this point will be given in another contribution dealing specifically with this feature.

*Colors.*—A rather dull-colored medusa, the umbrella being almost transparent with pale yellowish pink, slightly more noticeable in the region of the gonads, which share in the same general color; the tentacles are dull reddish occasionally. There is often noticeable a bluish opalescence over the entire exumbrella.

*Distribution.*—This is one of the commonest of the Atlantic coast medusæ and ranges from Maine to New York. It is most abundant during early summer along the New England coast. Its life history has been described by Agassiz (Contributions Natural History United States). The breeding season seems to extend throughout most of the spring and summer. Smith (Museum Comparative Zoology, Vol. XXII, p. 115) has worked out the early embryology with much care. The scyphistoma period remains somewhat uncertain. In this stage the larvæ certainly in some cases live through the winter season and become free ephyræ in early April and May, when I have taken them in all stages of metamorphism. I have kept the polyps for weeks during the summer in aquaria, and while they budded and stolonized freely, they showed no signs of strobilization. The text cut shows one such colony, which was reared in a small dish upon my laboratory table.

### PHACELLOPHORA Brandt (1835).

### Phacellophora ornata (Verrill).

*Callinema ornata* Verrill, American Journal Arts and Sciences, 1869, p. 117. Annals and Magazine Natural History, Vol. IV, 1869, p. 160.

*Phacellophora ornata* Haeckel, System der Medusen, 1879, p. 643.

Umbrella flat and disk-shaped, rather thick and rounded aborally, the exumbrellar surface covered with wart-like papillæ; walls transparent and with prominent radial canals which are of two sorts, one branching and anastomosing, the other simple and straight, each 16 in number. Margin with 16 lobes deeply incised, within the sinuses of which is located a prominent rhopalium. Tentacles numerous and of varying size and length, arising from the under surface of the margin beneath the circular canal. Manubrium large and pendulous and with prominent plaited oral arms. Gonads 8, in prominent pouches within the gastric cavity. Specimens vary in size from 10 to 18 inches in diameter.

*Distribution.*—Taken at Eastport, Me., by Verrill and later by Fewkes, from whose description (Bulletin Comparative Zoology, Vol. XIII) this account is chiefly compiled. So far as known to me the species has not been taken in the Woods Hole region, but, like others of similar range, its occurrence is not improbable.

## Family CYANEIDÆ.

Rhopalia 8; tentacles very numerous and long, disposed in 8 clusters, each comprising several rows ................ *Cyanea*

### CYANEA Peron & Lesueur (1809).

### Cyanea arctica Peron & Lesueur.

*Cyanea arctica* Peron & Lesueur, Tableau des Meduses, etc., 1809, p. 363. L. Agassiz, Contributions Natural History United States, Vol. IV, 1862, pp. 87, 162. A. Agassiz, North American Acalephæ, 1865, p. 44. Haeckel, System der Medusen, 1879, p. 530.

*Medusa capillata* Fabricius, Fauna Groenlandica, 1780, p. 364.

*Cyanea capillata* Eschscholtz, System der Medusen, 1829, p. 68.

*Cyanea postelsii* Gould, Report Invertebrates of Massachusetts, 1841, p. 347. Stimpson, Marine Invertebrates Grand Manan, 1853, p. 11.

*Cyanea fulva* L. Agassiz, op. cit. A. Agassiz, op. cit.

*Cyanea versicolor* L. Agassiz, op. cit. A. Agassiz, op. cit.

Umbrella flat and discoid, with a central aboral convexity; marginal lobes 8, with 16 or more secondary lappets. Marginal tentacles very numerous, in 8 clusters composed of several series of rows, the tentacles very long. This is one of the largest of our medusæ, often reaching a diameter of several feet, and with tentacles 50 feet or more in length when fully extended. The stomach is large, and there are normally 16 gastric pouches, 8 ocular, rather small and somewhat triangular, and 8 tentacular, much broader. The gonads are massive, extending the genital pouches into pendulous sacs hanging about the margin of the manubrium, which is long and with complex oral arms hanging in plaited folds within the circle of tentacles.

*Cyanea*, like *Aurelia*, presents numerous variations, not only in numerical and structural features, but in color, size, etc.

*Colors.*—Umbrella brownish to purplish, alternating with areas of transparency over the exumbrellar surface. Gonads yellowish white; tentacles variously colored, yellowish, orange, brown.

*Distribution.*—Almost the entire coast from Maine to North Carolina or beyond. This species is rather distinctively an arctic medusa, and is most abundant in early spring, though occasionally occurring in midsummer.

L. Agassiz has described two other species of *Cyanea*, namely, *C. fulva* and *C. versicolor*. I have not been able to recognize any constant differences of sufficiently marked character to warrant the conclusion of their specific distinctness. Collections made from a wide range of New England coast waters and southward to the Gulf Stream show every feature of intergradation among these supposed species and the preceding so fully as to preclude any definite line of separation between them. It would seem doubtful whether they were even entitled to varietal distinction, so intimate is the blending of varietal characters among medusæ taken within the same region.

## Family PELAGIIDÆ.

### KEY TO THE GENERA.

| | | |
|---|---|---|
| 1. | Marginal tentacles 8, marginal lobes 16 | *Pelagia* |
| 2. | Marginal tentacles 24; marginal lobes 32 | *Chrysaora?* |
| 3. | Marginal tentacles 40, less in young specimens; marginal lobes 48 | *Dactylometra* |

## **DACTYLOMETRA L. Agassiz** (1862).

### **Dactylometra quinquecirra** (Desor). Pl. VII, fig. 2.

*Pelagia quinquecirrha* Desor, Proceedings Boston Society Natural History, Vol. III, 1848, p. 76.

*Dactylometra quinquecirra*, L. Agassiz, Contributions to Natural History of United States, 1862, Vol. IV, pp. 125, 166. A. Agassiz, North American Acalephæ, 1865, p. 48. Haeckel, System der Medusen, 1879, p. 518.

Umbrella rather high and arched aborally, much as in *Pelagia*, disk about three times as broad as high. Manubrium long and pendulous, and with 4 slender oral arms, which are more or less frilled, as in the preceding. Rhopalia 8, marginal tentacles 40, marginal lobes 48. The tentacles are arranged in the adults with 5 between each 2 rhopalia. In immature specimens there are usually but 3 in these octants. Gonads in 4 masses within the gastric pouches, beneath each of which is a rather large subgenital pit on the subumbrellar surface. In size this medusa varies in the adult from 80 to 150 mm. in broad diameter.

*Colors.*—In general, similar to those of *Pelagia cyanella*, though generally less brilliant, the various hues being paler and somewhat more delicate. Exumbrella delicate bluish, mottled with reddish brown, fading into yellowish; tentacles reddish to orange; oral arms pale pinkish, varying to bluish.

*Distribution.*—Rather more limited than either *Aurelia* or *Cyanea*. It is a common medusa at Woods Hole, in Buzzards Bay, Vineyard Sound, and at Nantucket.

Like several of the previous species, *Dactylometra* exhibits more or less variation. According to Mayer (Bulletin Museum Comparative Zoology, XXXII, No. 7), the tertiary tentacles arise invariably on either side of the ocular lappets. In several specimens examined during the summer of 1902 they were found to arise at intermediate points between the primary and secondary sets. Again, according to the same observer, the tertiary tentacles appear only as the medusa approaches sexual maturity, and after attaining a diameter of 130 mm. On the contrary, I have found them well developed in specimens having a diameter of only 40 mm. and where no gonads were yet developed. The variation in the number of marginal lobes also was found to be about the same as in the previously mentioned species.

### PELAGIA Peron & Lesueur (1809).

#### Pelagia cyanella Peron & Lesueur. Pl. VII, fig. 1.

*Pelagia cyanella* Peron & Lesueur, Tableau des Meduses, etc., 1809, p. 349. Eschscholtz, System der Acalephen, 1829, p. 75. L. Agassiz, Contributions Natural History United States, Vol. IV, 1862, p. 164. A. Agassiz, North American Acalephæ, 1865, p. 47. Haeckel, System der Medusen, 1879, p. 507.

Umbrella somewhat dome-shaped, or subhemispherical; marginal lobes 16, with 8 rhopalia and 8 tentacles symmetrically disposed in the sinuses of the marginal lobes. Gonads 8, forming conspicuous pouch-like masses within the gastric pouches of the tentacular radii. Manubrium large and pendulous, with 4 variously frilled oral arms approximately as long as the tentacles.

*Colors.*—Disk translucent bluish, sprinkled with reddish brown dots over the exumbrellar surface, though more numerous near the margins and along certain radial areas, and forming crescent-like loops on the marginal lappets; manubrium similarly mottled on the outer edges of the arms, inner edges and frills delicate flesh colored; tentacles dull madder red to brownish red. Gonads pale purplish. Like *Dactylometra*, the color of *Pelagia* is more or less variable in different specimens.

This is a rare medusa in this region, only two specimens having been taken recently, both southward from Marthas Vineyard in the region of the Gulf Stream. Distribution chiefly pelagic.

According to Agassiz (above citation) the development of this medusa is direct, skipping the polyp and strobila stages and transforming directly from the planula to the ephyra and medusa.

## CTENOPHORA.[a]

While there continues to be widespread uncertainty as to the exact systematic relations of the ctenophores, there can be little doubt as to their more or less general relationship with the coelenterate phylum, hence their inclusion in the present synopsis.

In general they may be considered free-swimming medusoid cœlenterates of pelagic habit, wholly destitute of the polyp phase of the preceding classes. Moreover, there is lacking any tendency to a colonial habit, so characteristic of the pelagic siphonophores, budding or proliferous asexual reproduction being unknown among them. Ciliary locomotion, so characteristic a larval condition in the former group, continues throughout the entire life of ctenophores, though the cilia become greatly modified, appearing as plates occupying definite meridional areas over the body. Tentacles may be entirely lacking, and when present are but two in number and located on opposite sides of the body, in perradial planes, and capable of contraction within lateral pockets. Again, nematocysts, so distinctive a feature of the classes previously described, are wholly lacking here, though certain cells of the etoderm of the tentacles, known as adhesive cells, may possibly be regarded as homologous with them, and may aid in taking prey.

The gastrovascular system is well developed. The stomodeum, or so-called stomach, is usually large and opens above into the principal cavity of the canal system, the so-called funnel, or infundibulum. This divides into 8 terminal branches occupying adradial positions at their peripheral extremities. The stomach and funnel planes of the body are at right angles, and comprise the perradial planes known, respectively, as stomach and funnel planes. There are no signs of gastral filaments.

The muscular system is but slightly developed as such, though there are numerous muscular fibers intricately distributed through the mesoglœa. Many of these fibers are curiously branched and polynucleated.

---

[a] This account presents merely the briefest synopsis of the species found within the region.

The nervous system, or rather tissue, seems chiefly limited to the aboral pole and concentrated about the sensory body (otocyst ?), whose function is probably that of equilibrium.

In form the Ctenophora are for the most part ovoid, pyriform, or spherical organisms, of extreme delicacy of texture, making it almost impossible to lift a specimen from the water without its dissolving into a bit of formless slime. *Cestus*, or Venus's girdle, is a rare exception to the usual shape already indicated. In this form the body is greatly extended in the stomach plane and flattened in the funnel plane.

Ctenophores are hermaphrodite, the gonads being borne on opposite sides of the canals. Development is direct for the most part, in only a few cases showing metamorphic phases.

The Ctenophora are distinguishable into two fairly well-defined sections, namely, those with tentacles and those without tentacles, or

TENTACULATA.—With more or less evident tentacles, at least during the earlier larval history.

NONTENTACULATA.—Devoid of tentacles during entire life history.

## TENTACULATA.

### ORDER CYDIPPIDÆ.

Body more or less spherical or cylindrical, with two simple or pinnate tentacles which are retractile within lateral pockets. Aboral pole without wing-like processes.

### Family MERTENSIIDÆ.

Body somewhat compressed in the gastric plane, subtentacular ridges longer than the subgastric.

**MERTENSIA Lesson** (1843).

**Mertensia ovum** (Fabricius).

*Beroe ovum* Fabricius, Fauna Groenlandica, 1780, p. 362.
*Cydippe ovum* Eschscholtz, System der Acalephen, 1829, p. 25.
*Beroe pileus* Scoresby, Arctic Regions, 1820.
*Mertensia scoresbyi* Lesson, Histoire Naturelle des Zoophytes Acalephes, 1843.
*Mertensia ovum* A. Agassiz, North American Acalephæ, 1865, p. 26. Chun, Die Ctenophoren der Plankton-Expedition, 1898, p. 10.

Body subspherical to pyriform, from 16 to 18 mm. in diameter. According to A. Agassiz this species is distinguished by a peculiar whirling motion in swimming, and by a distinct pinkish color; body somewhat flattened. Only rarely taken at Woods Hole; commoner northward.

### Family PLEUROBRACHIIDÆ.

Body pyriform to spherical; subtentacular and subgastric ridges of about equal length.

**PLEUROBRACHIA Flemming** (1822).

**Pleurobrachia pileus** (Fabricius).

*Beroe pileus* Fabricius, Fauna groenlandica, 1780, p. 361. Flemming, History British Animals, 1828, p. 504.
*Cydippe pileus* Eschscholtz, System der Acalephen, 1829, p. 24.
*Pleurobrachia rhododactyla* L. Agassiz, Memoirs American Academy, Vol. IV, 1849, p. 314.
*Pleurobrachia pileus* L. Agassiz, Contributions to Natural History of the United States, Vol. III, 1860, p. 203. Chun, Die Ctenophoren Plankton-Expedition, 1898, p. 15.

Very similar to the preceding species, size 18 to 20 mm.; nearly spherical in form; tentacles long and feathered or pectinate; the 8 series of vibratile plates prominent. One of the commonest of our early ctenophores, as well as one of the most beautiful and of a firmer texture than any others of this order, making it possible to preserve fairly well specimens that have been properly killed.

*Distribution.*—Chiefly northward, though common during early spring in Woods Hole and adjacent waters.

### ORDER LOBATA.

Body compressed laterally; that is, gastric plane longer than that of the funnel. Oral region with 2 lateral lobes, and with 4 auricles. Tentacles in lateral furrows.

### Family LESUEURIIDÆ.

Marginal lobes somewhat rudimentary, auricles long and ribbon-like.

#### **LESUEURIA M. Edwards** (1841).

#### **Lesueuria hyboptera** A. Agassiz (1865).

*Lesueuria hyboptera* A. Agassiz, North American Acalephæ, 1865, p. 23. Chun, Die Ctenophoren der Plankton-Expedition, 1898, p. 22.

Body large and nearly rectangular as viewed from the broad aspect. Aboral pole deeply pitted with sensory body at its bottom. Very transparent and highly phosphorescent. Somewhat like *Mnemiopsis*, though distinguishable by the greater flattening and by the rectangular aspect.

*Distribution.*—Newport, R. I., Woods Hole, Massachusetts Bay.

### Family BOLINIDÆ.

Lobes of medium size, auricles short.

#### **BOLINA Mertens** (1833).

#### **Bolina alata** L. Agassiz.

*Bolina alata* L. Agassiz, Memoirs American Academy Arts and Sciences, Vol. IV, 1849, p. 349. Contributions to Natural History United States, Vol. III, 1860, p. 268. A. Agassiz, North American Acalephæ, 1865, p. 15. Chun, Die Ctenophoren der Plankton-Expedition, 1898, p. 22.

Similar in general form and size to *Mnemiopsis*, but more distinctly compressed.

Described by Agassiz as one of the commonest species in Massachusetts Bay, it is, however, rather rare south of Cape Cod, being seldom found at Woods Hole.

### Family MNEMIIDÆ.

Lobes large and arising from about the level of the funnel, which is also the level of origin of the auricles, and these are long and ribbon-like.

#### **MNEMIOPSIS L. Agassiz** (1860).

#### **Mnemiopsis leidyi** A. Agassiz.

*Mnemiopsis leidyi* A. Agassiz, North American Acalephæ, 1865, p. 20. Fewkes, Bulletin Museum Comparative Zoology, Vol. IX, p. 291.

This is one of our largest and commonest ctenophores, specimens often measuring 100 mm. or more in polar diameter by about half that width in narrow diameter. The marginal lobes are long and pendulous, extending far below the mouth level. As seen in profile the outline is somewhat triangular, specially when fully expanded. In contraction the lobes are curved inward, closing tightly over the mouth and giving an oval outline to the animal. The tentacles are rudimentary in the adult, though quite well developed in the young. *Mnemiopsis* is brilliantly phosphorescent, emitting sudden flashes of light when disturbed at night by a dipping oar or other cause.

Common throughout the region, and usually very abundant during summer and early autumn.

### ORDER CESTIDÆ.

Body greatly elongated and ribbon-like.

#### CESTUS Lesueur (1813).

#### Cestus veneris Lesueur.

*Cestus veneris* Lesueur, Nouveau Bulletin de la Société Philomatique, 1813, p. 281. Chun, Ctenophoren Plankton-Expedition, 1898, p. 20.

This is a distinctively tropical species and rarely found beyond a tropical range. It has been reported by S. I. Smith from Georges Bank, and A. Agassiz has reported fragments of a single specimen found at Newport, R. I.

### NONTENTACULATA.

Ctenophora wholly devoid of tentacles.

Only the order Beroida, family Beroidæ, has representatives in this region. The body is ovoid, usually somewhat compressed laterally. Mouth very large, opening into a capacious stomach. Radial canals with lateral and variously anastomosing branches.

#### BEROE Browne (1756).

#### Beroe ovata Bosc. Text cut.

*Beroe ovata* Bosc, Histoire Naturelle des Vers, 1802, p. 149. Fewkes, Bulletin Museum Comparative Zoology, Vol. IX, p. 251.

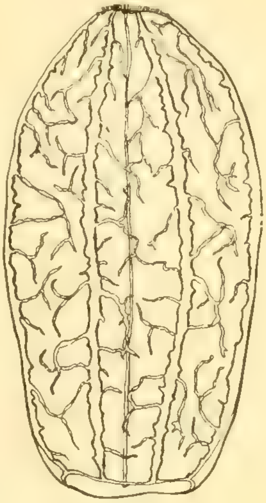
*Idyia ovata* Lesson, Histoire Naturelle Zoophytes Acalephes, 1843, p. 134.

*Idyiopsis clarkii* L. Agassiz, Contributions Natural History United States, Vol. III, 1860, pp. 288, 296.

*Idyiopsis affinis* L. Agassiz, Contributions Natural History United States, Vol. III, 1860, pp. 288, 296.

One of our finest ctenophores. Body large, measuring 40–70 mm. in polar diameter, with about half the width. Margins plain and capable of slight evagination or contraction. Radial canals 8, extending to the margin and otherwise connected with numerous anastomosing lateral branches. Ciliary areas prominent and of beautiful pinkish hue.

Common at Woods Hole in 1901, though seldom taken in any considerable numbers.



*Beroe ovata.*

#### Beroe cucumis Fabricius.

*Beroe cucumis* Fabricius, Fauna Grœnlandica, 1780, p. 361. Eschscholtz, System der Acalephen, 1829, p. 36. Chun, Ctenophoren der Plankton-Expedition, 1898, p. 26.

*Idyia borealis* Lesson, Natural History der Zoophytes Acalephes, 1843, p. 134.

*Medea arctica* Lesson, Natural History der Zoophytes Acalephes, 1843, p. 134.

*Idyia roseola* L. Agassiz, Contributions Natural History United States, Vol. III, 1862, pp. 270 and 290.

*Idyia cucumis* A. Agassiz, North American Acalephæ, 1865, p. 36.

This, like the preceding, is a most beautiful ctenophore, of splendid roseate hue, varying in size from 15–20 mm. in polar diameter, with about half the breadth. In general aspects it is much like the preceding, though much smaller and more brightly colored.

Range, according to Verrill, from Vineyard Sound to Labrador. Reported by Agassiz from coast of New England. Taken by the writer in 1902 off Crab Ledge, near Chatham, Mass.

## LITERATURE CITED.

Only the more important citations of authorities are included in the following list:

Agassiz, A., Catalogue of North American Acalephæ. Cambridge, 1865.

Agassiz, A., and Mayer, A. G., Medusæ of the Pacific. Memoirs Museum Comparative Zoology, Vol. XXVI, Cambridge, 1902.

Agassiz, L., Contributions to the Natural History of the United States, Vols. III and IV. Boston, 1860–1862.

——— Memoirs American Academy of Arts and Sciences, 1849.

Allman, J. G., A Monograph of the Gymnoblastic Hydroids. London, 1871.

——— Numerous papers in Annals and Magazine of Natural History.

Ayres, W. O., Proceedings Boston Society of Natural History, 1852, etc.

Brandt, J. F., Prodromus Descriptionis Animalium, etc. Académie Impériale des Sciences de St.-Pétersbourg, 1833–34.

Brooks, W. K., The Life History of North American Hydromedusæ, Boston, 1886.

——— Studies from the Johns Hopkins University, Vol. IV, 1888.

Browne, E. T., Variation in Aurelia aurita. Biometrica, Vol. I, 1901.

Cavolini, Filipo, Memorie de Polypi Marini. Napoli, 1785.

Chun, Carl, Bronn's Classen und Ordnungen des Thier-Reichs. Leipzig, 1889–1900.

——— Die Ctenophoren der Plankton-Expedition. Leipzig, 1897.

——— Die Siphonophoren der Plankton-Expedition. Leipzig, 1898.

Clark, H. J., Prodromus of the History, Structure, etc., of the Lucernaridæ. Journal Boston Society Natural History, 1863.

——— American Journal Arts and Sciences, May, 1863.

——— Monograph of the Lucernariæ. Smithsonian Contributions to Knowledge, Vol. XXIII, Washington, 1878.

Cuvier, Geo. Leop. Le Règne Animal. Paris, 1817.

Delage and Hérouard, Traité de Zoologie Concrète, Les Coelentérés, 1901.

Desor, E., Proceedings Boston Society Natural History, 1848–49, Vol. III.

Eschscholtz, Joh. Friedr., System der Acalephen. Berlin, 1829.

Fewkes, J. W., Various papers in Bulletin Museum Comparative Zoology. Cambridge.

Forbes, Edw., British Naked-eyed Medusæ. London, 1848.

Forskal, P., Descriptiones Animalium, etc., Havniæ, 1775.

——— Icones Rerum, Naturalium, etc., Havniæ, 1776.

Gegenbaur, Carl, Versuch eines Systemes der Medusen. Zeitschrift für Wissenschaftlichen Zoologie, 1857.

Haeckel, E., Prodromus Systemæ Medusarum. Jena, 1877.

——— System der Medusen. Jena, 1879.

——— Siphonophora. Challenger Report, Zoology, Vol. XXVIII, 1888.

——— Monographie der Medusen. Jena, 1881.

Hargitt, C. W., Synopsis of Hydromedusæ and Scyphomeduse. American Naturalist, Vols. XXXV and XXXVII, 1901 and 1903.

——— American Naturalist, Vols. XXXIV and XXXVI, 1900 and 1902.

——— Biological Bulletin, Vols. II and IV, 1901–2.

Hertwig, O., and R., Der Organismus der Medusen. Jena, 1878.

Hincks, T., British Hydroid Zoophytes. London, 1868.

——— Various papers in Annals and Magazine Natural History.

Huxley, T. H., The Oceanic Hydrozoa. London, 1859.

Johnston, Geo., A History of British Zoophytes. Edinburgh, 1847.

Kölliker, A., Icones Histiologicæ, 1864–65.

Lamarck, Chevalier de, Des Animaux sans Vertèbres. Paris, 1836.

Lamouroux, J. V. F., Histoire des Polypiers Coralligènes Flexible, etc., 1816.

Lendenfeld, R., Australian Hydromedusæ. Proceedings Linnæan Society of New South Wales, Sydney, 1884.

——— Coelenteraten der Süd-See. Zeitschrift für wissenschaftlichen Zoologie, 1888.

Leidy, Jos., Marine Invertebrate Fauna of New Jersey and Rhode Island. Journal Academy of Sciences, Philadelphia, Vol. III, 1855.

Lesson, R. P., Histoire Naturelle des Zoophytes Acalèphes. Paris, 1843.

Maas, Otto, Die Craspedoten Medusen der Plankton-Expedition. Leipzig, 1893.

Mayer, A. G., various papers in Bulletin Museum Comparative Zoology, Vols. XXXII and XXXVII.

MAYER, A. G., Medusæ of the Bahamas. Memoirs of Natural Sciences, Brooklyn Institute of Arts and Sciences, Vol. I, 1904.

McCRADY, J., Gymnophthalmata of Charleston Harbor. Proceedings of Elliott Society Natural History, Vol. I, 1853–1858.

MÜLLER, O. F., Zoologia Danica, etc., 1788–89.

NUTTING, C. C., Hydroids of the Woods Hole Region. Bulletin U. S. Fish Commission, Washington, 1901.

PALLAS, P. S., Elenchus Zoophytorum, etc., 1776.

PERON, F., and LESUEUR, C. A., Tableau des Méduses, etc. Annales du Museum d'Histoire Naturelle, No. XIV, 1809.

SARS, M., Fauna Littoralis Norvegiæ, Christiania, 1846.

SOLANDER, D., Natural History of Curious and Uncommon Zoophytes. London, 1736.

STEENSTRUP, J. J., Über den Generationswechsel . . . in den niedern Thierclassen, 1842.

STIMPSON, Marine Invertebrates of Grand Manan. Smithsonian Contributions to Knowledge, Vol. VI, Washington, 1853.

VERRILL, A. E., Invertebrate Animals of Vineyard Sound. Report U. S. Fish Commission, 1871.

# INDEX.

The following index refers chiefly to names of families, genera, and species. Generic synonyms are printed in italics.

Page.
ÆGINA 58
  pachyderma 58
ÆGINIDÆ 58
ÆQUOREA 51, 52
  albida 52
ÆQUOREIDÆ 42, 51
*Agalma* 60
AGLANTHA 55
  conica 56
  digitalis 55
AGLAURA 55
  hemistoma 55
AGLAURIDÆ 55
*Amphinema* 35
ANTHOMEDUSÆ 28, 29
ANTHOPHYSA 60
  formosa 60
*Armenista* 59
ATOLLA 67
  bairdii 67
  verrilli 67
*Athorybia* 60
AURELIA 67
  flavidula 67
BATHYLUCA 66
  solaris 66
BEROE 73
  cucumis 73
  ovata 73
BEROIDA 73
BEROIDÆ 73
BOLINA 72
  alata 72
BOLINIDÆ 72
BOUGAINVILLIA 37, 39
  carolinensis 39
  gibbsi 40
  superciliaris 40
CALCYONECTÆ 59
*Campanella* 58
CANNOSTOMÆ 65
CANNOTIDÆ 42
*Catablema* 36
CESTIDÆ 73
CESTUS 73
  veneris 70
CHARYBDEA 65
  verrucosa 65
*Circe* 55
CLADONEMIDÆ 29, 41

Page
CLYTIA 45, 46
  bicophora 46
  nolliformis 47
CODONIDÆ 29
CORYMORPHA 30, 32
  pendula 34
*Coryne* 30
CORYNITIS 41, 42
  agassizii 42
CTENOPHORA 28, 70
CUBOMEDUSÆ 62, 64
CUNANTHIDÆ 57
CUNINA 57
  discoides 57
CUPULITA 60
  cara 60
CYANEA 68
  arctica 68
  fulva 69
  versicolor 69
CYANEIDÆ 65, 68
*Cydippe* 71
CYDIPPIDÆ 71
CYSTONECTÆ 61
DACTYLOMETRA 69
  quinquecirra 69
*Dinamatella* 35
DIPHYES 59
  bipartita 59
*Diplophysa* 61
DIPHYOPSIS 60
  campanulifera 60
DIPURELLA 29, 31
  clavata 31
DIPURENA 29, 30
  conica 31
  strangulata 30
DISCOMEDUSÆ 62, 65
DISCONECTÆ 59
DYSMORPHOSA 37, 38
  fulgurans 38
*Dyscannota* 40
ECTOPLEURA 29, 32
  ochracea 32
*Eucope* 55
EPENTHESIS 45, 50
  folleata 50
EPHYRIDÆ 65, 66
EPHYROIDES 66
  rotaformis 66

Page.

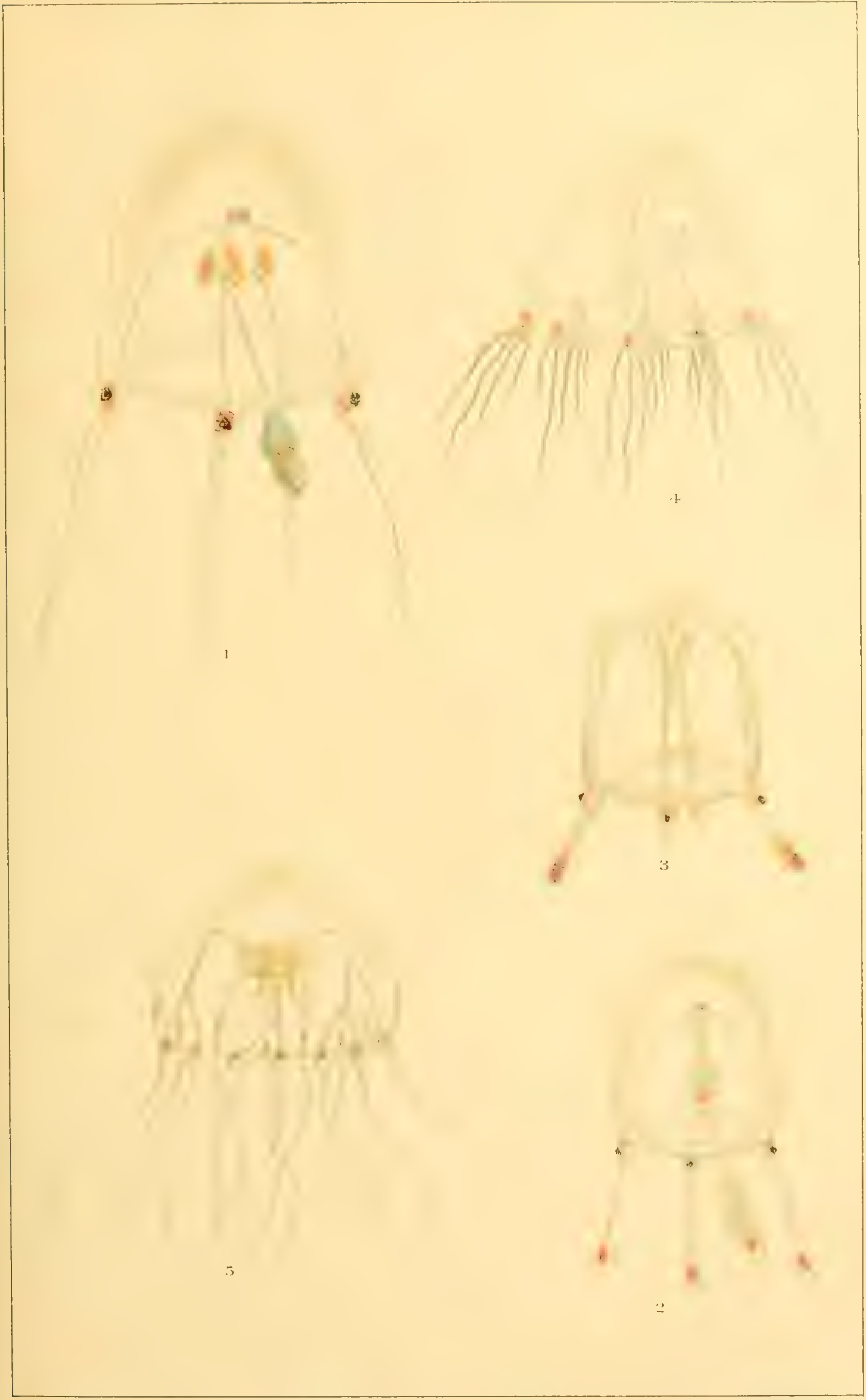
- Eucheilota, 45, 46
  - duodecimalis, 46
  - ventricularis, 46
- *Eucope*, 48, 49
- Eucopidæ, 42, 45
- *Eucoryne*, 32
- Euphysa, 30, 33
  - virgulata, 33
- Eutima, 45
  - limpida, 46
  - mira, 45
- Gemmaria, 41
  - cladophora, 42
- *Gleba*, 60
- Geryonidæ, 56
- *Globiceps*, 32
- Glossocodon, 56, 57
  - tenuirostris, 57
- Gonionemus, 53
  - murbachii, 53
- *Gonionema*, 53
- Haliclystus, 63
  - auricula, 63
  - salpinx, 63
- Halicyathus, 63, 64
  - lagena, 64
- *Halocordyle*, 32
- *Halocharis*, 42
- Halopsis, 51
  - ocellata, 51
- *Hippocrene*, 40
- Hippopodius, 60
  - luteus, 60
- *Homœonema*, 54
- Hybocodon, 30, 33
  - prolifer, 33
  - pendula, 34
- Hydrichthys, 29, 32
  - mirus, 32
- Hydromedusæ, 28
- *Idyia*, 73
- *Idyopsis*, 73
- *Lafoea*, 43
- Laodicea, 43
  - calcarata, 43
- *Laomedia*, 48, 49
- Leptomedusæ, 29, 42
- Lesueuria, 72
  - hyboptera, 72
- Lesueuriidæ, 72
- Linerges, 67
  - mercurius, 67
- Linergidæ, 65, 67
- *Lirianthа*, 56
- Liriope, 56
  - cerasiformis, 56
  - scutigera, 56
- Lizzia, 37, 39
  - grata, 39
- Lucernaria, 62
  - quadricornis, 63
- Lucernariidæ, 62, 63
- *Manania*, 64
- Margelidæ, 29, 37
- *Margelis*, 39
- *Margelium*, 39
- Melicertum, 43, 44
  - campanula, 44
- Mertensia, 71
  - ovum, 71

Page.

- Mertensiidæ, 71
- Mnemiidæ, 72
- Mnemiopsis, 72
  - leidyi, 72
- *Modeeria*, 37
- *Monocaulus*, 34
- *Monophyes*, 61
- *Nanomia*, 60
- Narcomedusæ, 29, 57
- Nauphantopsis, 66
  - diomedeæ, 66
- Nausithoe, 66
  - punctata, 66
- Nemopsis, 37, 41
  - bachei, 41
- Obelia, 45, 47
  - commissuralis, 48
  - diaphana, 48
  - fusiformis, 49
  - gelatinosa, 48
  - pyriformis, 49
- Oceania, 45, 49
  - languida, 50
  - singularis, 50
- Orchistoma, 43, 44
  - tentaculata, 44
- Peganthidæ, 58
- Pelagia, 69, 70
  - cyanella, 70
- Pelagiidæ, 65, 69
- Pennaria, 29, 32
  - gibbosa, 32
  - tiarella, 32
- Perigonimus, 29, 33
  - jonesii, 33
- Periphylla, 64
  - humilis, 64
  - hyacinthina, 64
  - peronii, 64
- Peromedusæ, 62, 64
- Petasidæ, 53
- Phacellophora, 67, 68
  - ornata, 68
- Phialis, 45, 50
  - cruciata, 50
- *Phialidium*, 50
- Physalia, 61
  - pelagica, 61
- Pilemidæ, 65
- *Platypixis*, 47
- Pleurobrachia, 71
  - pileus, 71
- Pleurobrachiidæ, 71
- Podocoryne, 37, 38
  - carnea, 38
- *Polycanna*, 52
- Porpita, 59
  - linnæana, 59
- Protiara, 34
  - hæckeli, 34
- Ptychogena, 45
  - lactea, 45
- *Rhacostoma*, 52
- Rhegmatodes, 51
  - tenuis, 51
- Rhizostomæ, 65
- Rhopalonema, 54
  - typicum, 54
- *Saphenia*, 35

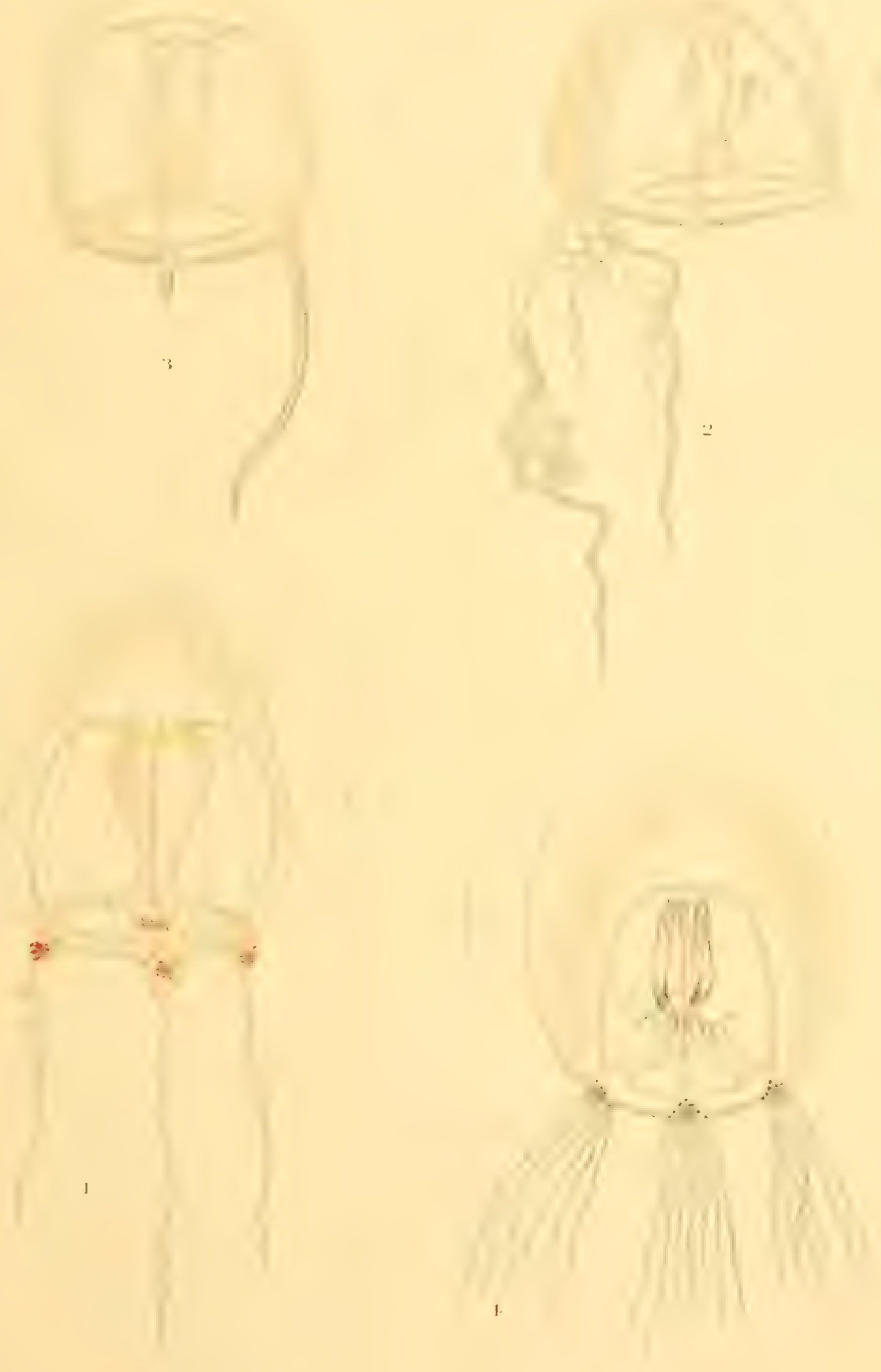
Page.
*Sarsia* 30
Scyphomedusæ 28, 61
Semostomæ 65
*Sertularia* 48
Siphonophora 29, 59
Solmaridæ 58
Solmaris 58
tetranema 58
Sphæronectes 61
gracilis 61
*Staurophora* 43
Stauromedusæ 62
Staurostoma 43
laciniata 43
Stomobrachium 51
tentaculatum 51
Stomotoca 34
apicata 35
rugosa 35
Stylactis 37, 41
hooperi 41
Syncoryne 29, 30
mirabilis 30
producta 30
reticulata 30
*Syndictyon* 30
Tessaridæ 62

Page.
Thaumantiidæ 42, 43
*Thaumantias* 48
Tiaridæ 29, 34
Tiaropsis 45, 49
diademata 49
Tima 45, 47
formosa 47
Torumidæ 65
Trachomedusæ 29
Trachynemidæ 51, 55
*Trachynema* 54
Turris 34, 36
episcopalis 36
vesicaria 36
Turritopsis 34, 37
nutricula 37
Ulmaridæ 65, 67
Velella 59
mutica 59
*Willetta* 40
Willia 37, 40
ornata 40
*Willsia* 40
*Zanclea* 42
Zygodactyla 51, 52
grœnlandica 52



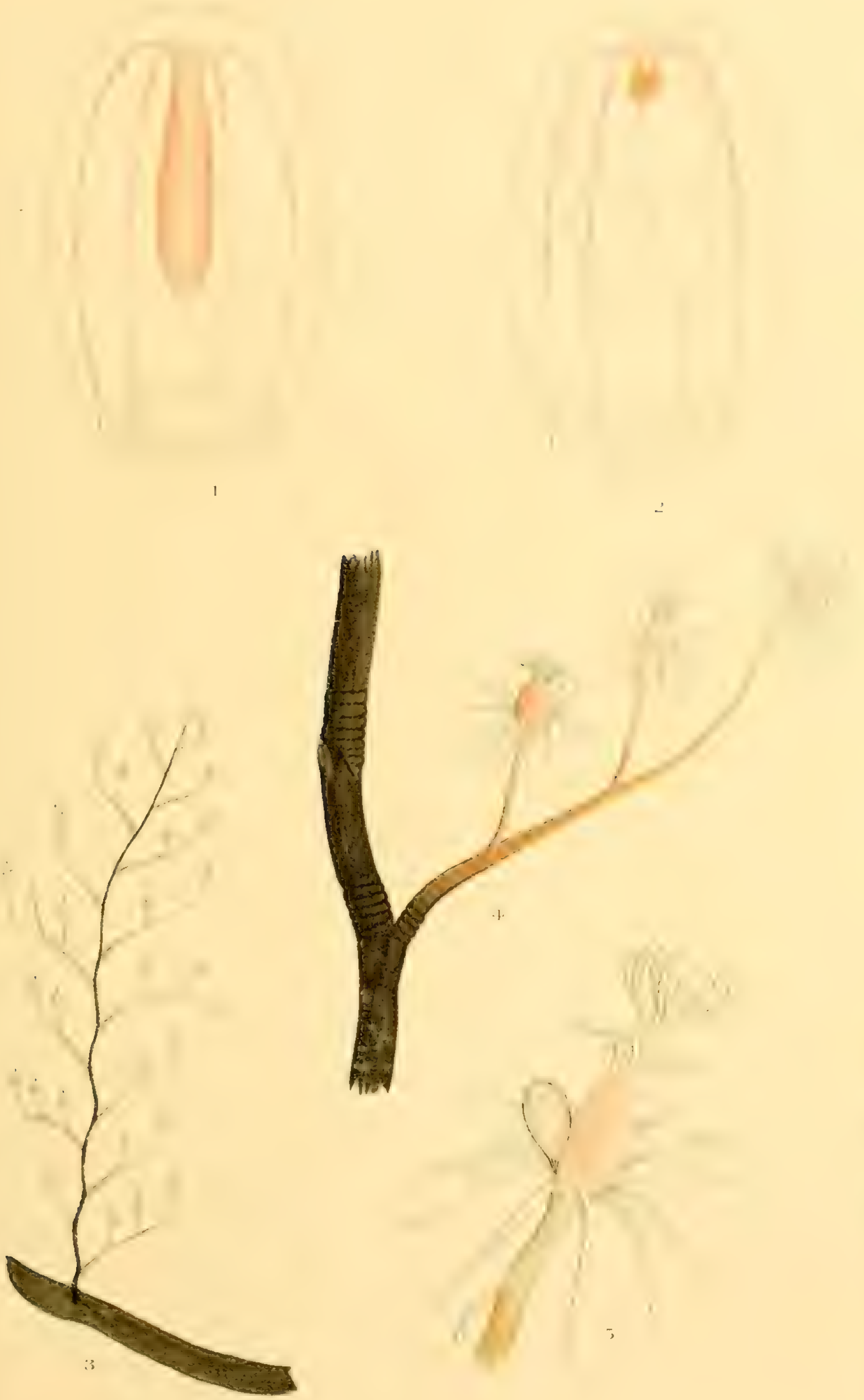
JULIUS BIEN & CO. N.Y.

1. SYNCORYNE PRODUCTA. 3. DIPURELLA CLAVATA.
2. DIPURENA STRANGULATA. 4. LIZZIA GRATA.
5. WILLIA ORNATA.



JULIUS BIEN & CO. N.Y.

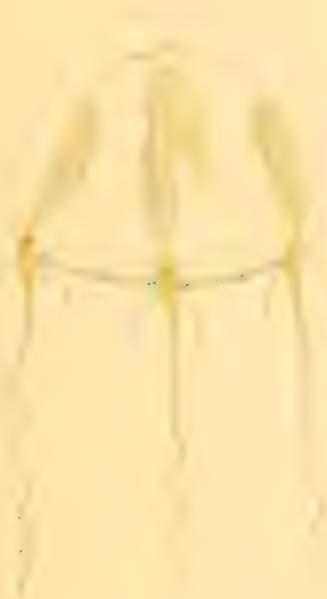
1. ECTOPLEURA OCHRACEA.
2. HYBOCODON PROLIFER.
3. HYBOCODON PENDULA.
4. BOUGAINVILLIA CAROLINENSIS.



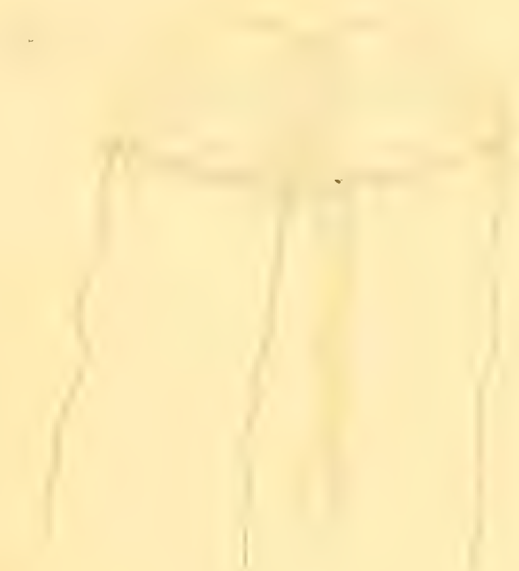
PENNARIA TIARELLA

1. MALE
2. FEMALE.
3 HYDROID
4. PORTION OF COLONY
5. SINGLE HYDRANTH WITH MEDUSOID

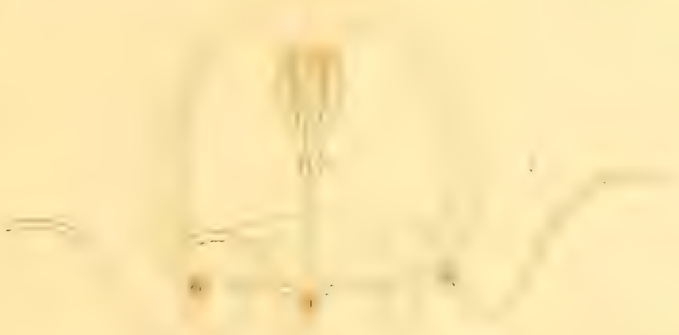
PLATE IV.



3

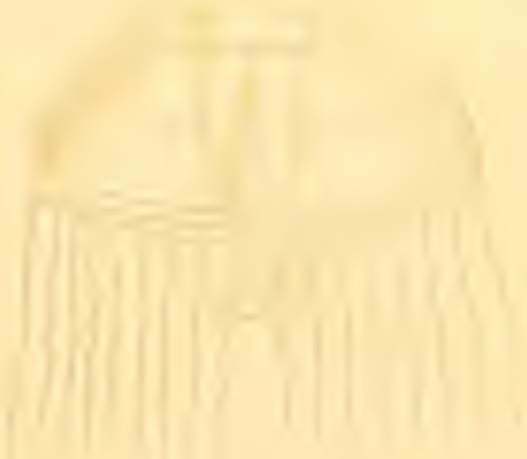


1



5

4

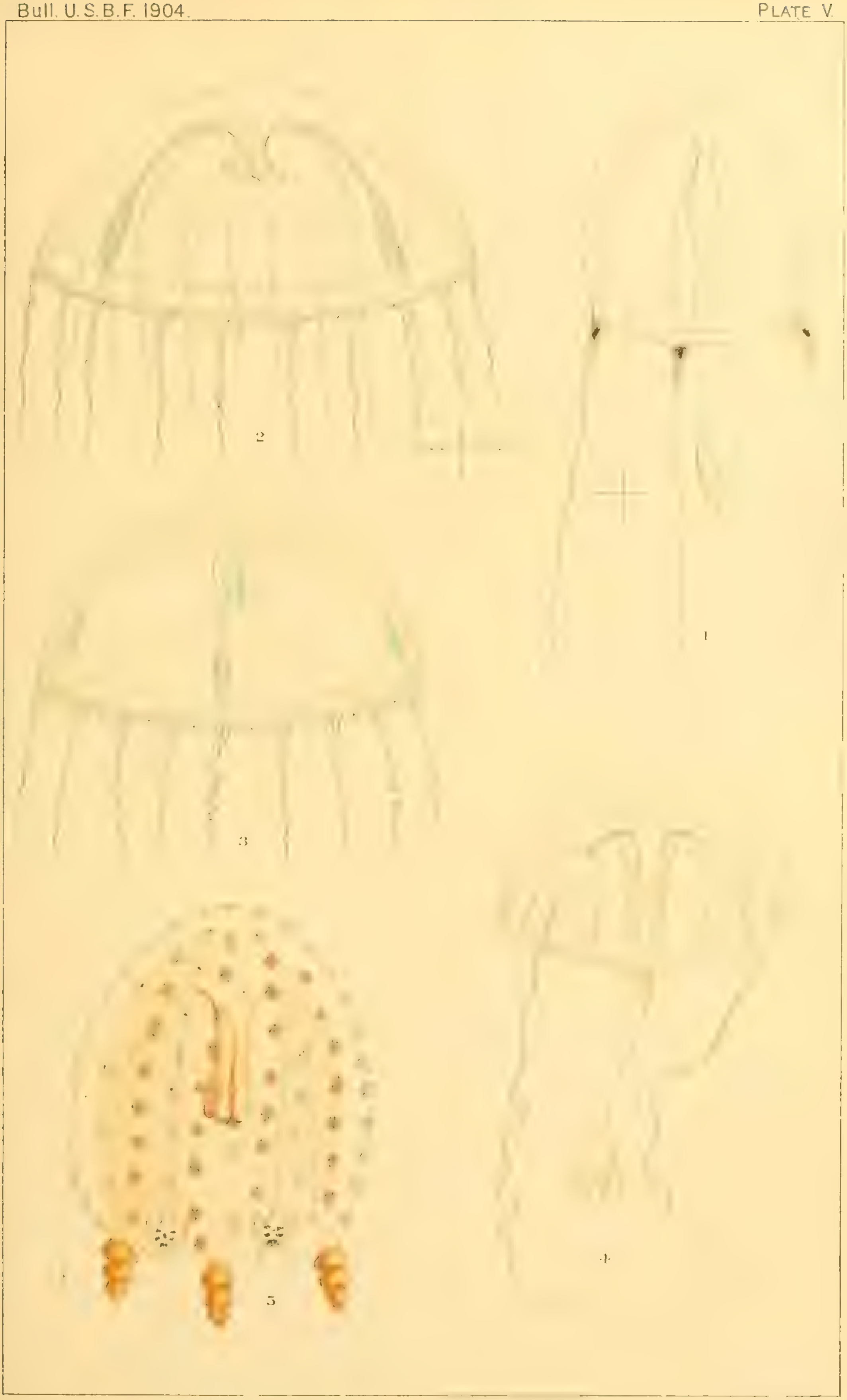


2

JULIUS BIEN & CO. N.Y.

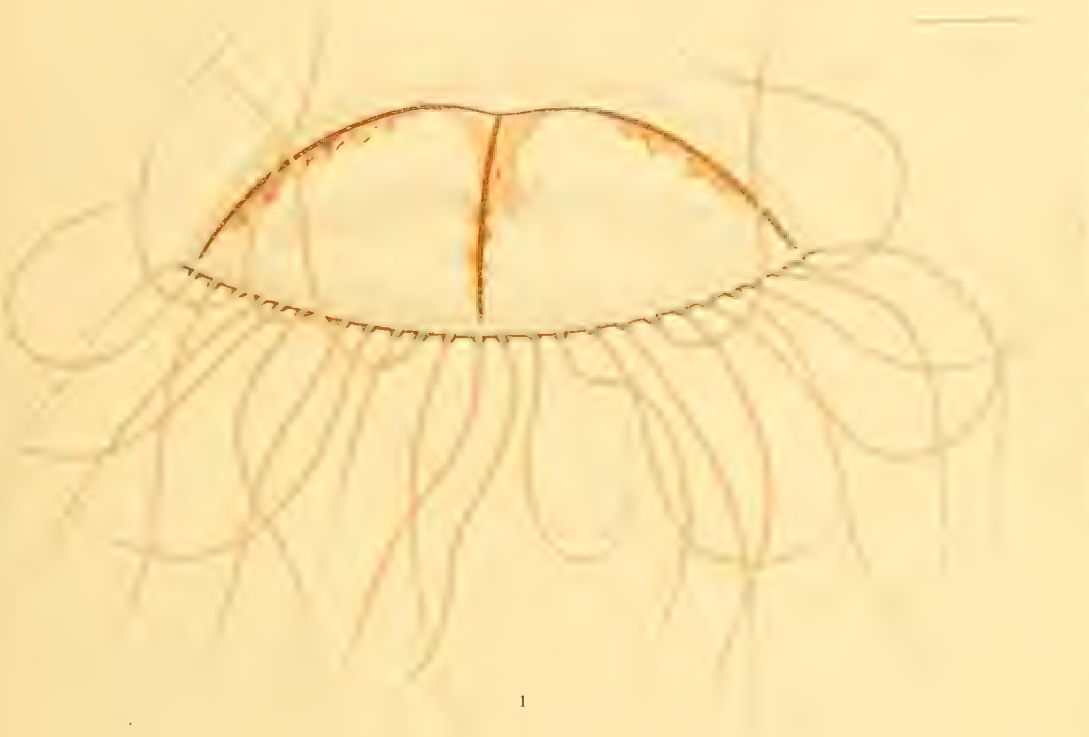
1. EUTIMA MIRA.
2. TIMA FORMOSA.
3. EUCHEILOTA DUODECIMALIS.
4. EUCHEILOTA VENTRICULARIS
5 PODOCORYNE CARNEA.

PLATE V.

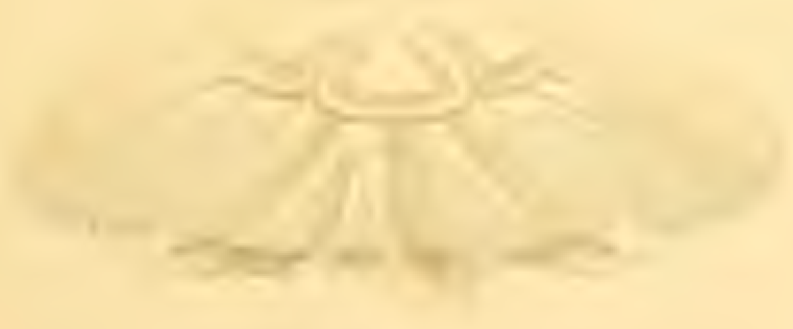


JULIUS BIEN & CO. N.Y.

1. Syncoryne mirabilis.
2. Oceania languida.
3. Epenthesis folleata.
4. Liriope cerasiformis.
5. Charybdea verrucosa.



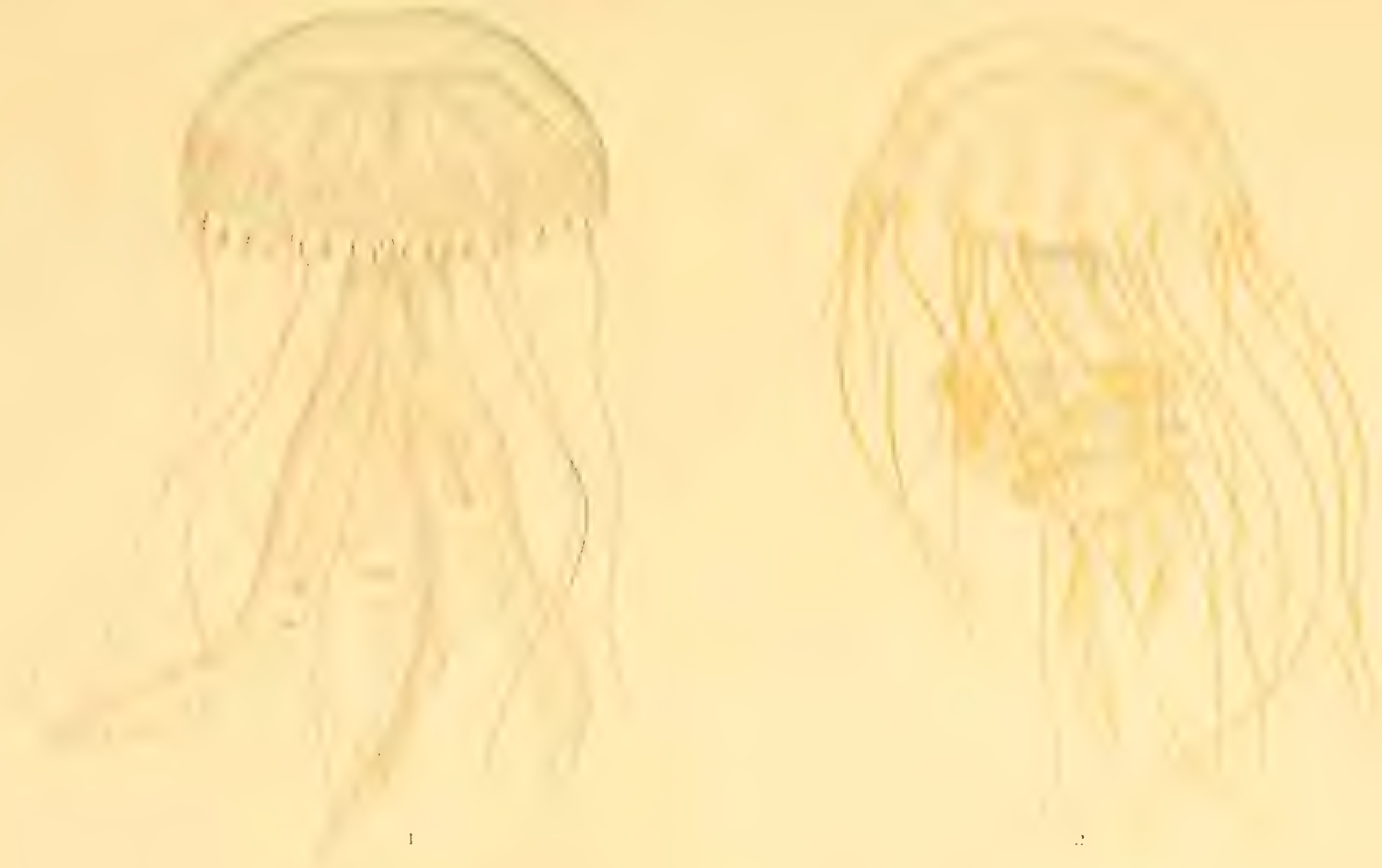
1



2

Julius Bien & Co. N.Y.

1. Gonionemus murbachii. 2 Aurelia flavidula.



JULIUS BIEN & CO. N.Y.

1. PELAGIA CYANELLA. 2. DACTYLOMETRA QUINQUECIRRA.

# THE OSTEOLOGY AND IMMEDIATE RELATIONS OF THE TILE-FISH, LOPHOLATILUS CHAMÆLEONTICEPS.

By FREDERIC A. LUCAS,
*Curator, Division of Comparative Anatomy, U. S. National Museum*

# THE OSTEOLOGY AND IMMEDIATE RELATIONS OF THE TILE-FISH, LOPHOLATILUS CHAMÆLEONTICEPS.

---

By FREDERIC A. LUCAS,
*Curator, Division of Comparative Anatomy,*
*U. S. National Museum.*

---

The genera *Latilus*, *Caulolatilus*, *Lopholatilus*, and *Malacanthus* have usually been grouped in one family, the Malacanthidæ, but Boulenger[a] adds to these *Opisthognathus*, *Bathymaster*, and *Rathbunella* to form his Pseudochromidæ. It was suggested by Doctor Jordan, in The Fishes of North and Middle America, that the family Malacanthidæ might not be a natural assemblage, and the present paper is an attempt to define its limits; the question of affinities with other species or families must await the accumulation of more material.

The skull of *Lopholatilus* is moderately elevated, with an occipital crest formed almost entirely by the supraoccipital, which extends forward between the frontals and is produced backward as a narrow tongue of bone running between the exoccipitals to the foramen magnum. In *Malacanthus* the supraoccipital is not extended forward between the frontals, nor is it produced backward between the exoccipitals, these bones interposing between the supraoccipital and the foramen magnum.

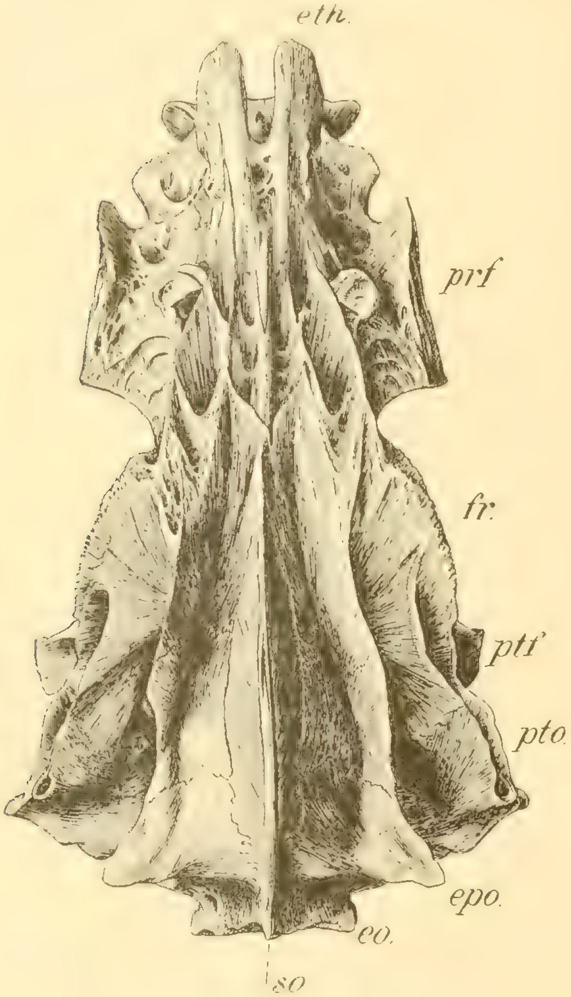
The mesethmoid extends well forward, slightly in advance of the vomer, and is deeply forked, while in *Malacanthus* there is a mere indication of a fork. The vomer is proportionately broader in *Lopholatilus*, as is also the parasphenoid, the anterior forks of which do not reach so far forward. At the same time the keeling of the parasphenoid in *Lopholatilus* is ∧-shaped in cross section, while in *Malacanthus* in the anterior part it is decidedly ⊥-shaped. In the particular characters mentioned, as in the general arrangement of the bones of the cranium and their relations with each other, *Latilus* and *Caulolatilus* agree with *Lopholatilus* and disagree with *Malacanthus*. A myodome is present in all these genera.

The number of vertebræ, not including the terminal semivertebra, is approximately the same in all the species under consideration, being in *Lopholatilus* 10 thoracic and 13 caudal, in *Latilus* 11 and 12, in *Caulolatilus* 12 and 14, and in *Malacanthus* 10 and 13. In *Malacanthus* the vertebræ are somewhat elongate and but lightly sculptured on the sides, while the other genera agree in having the vertebræ not elongated and rather deeply sculptured.

---

[a] Annals and Magazine of Natural History, 7th series, vol. 8, p. 270. In the same paper (p. 264) Boulenger gives excellent figures illustrative of the principal characters of the shoulder girdle of *Caulolatilus* and two of the genera with which the latilids have been associated.

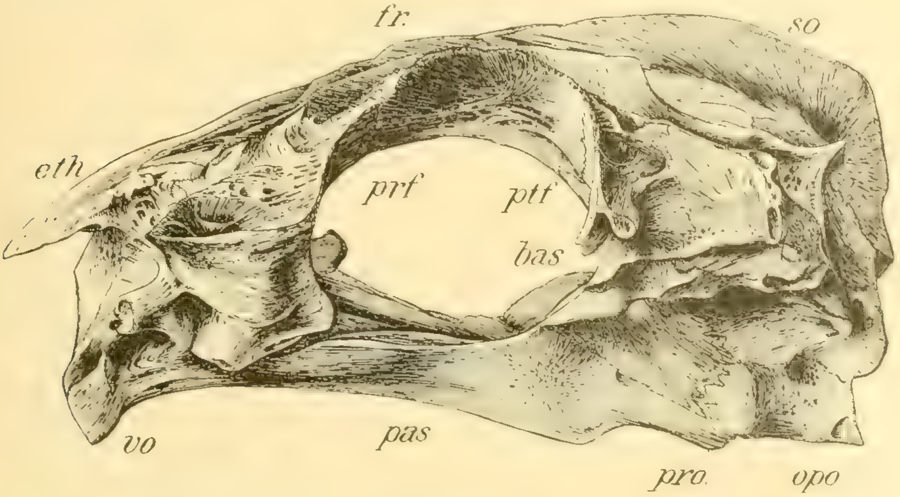
In *Lopholatilus* the parapophyses begin on the fourth vertebra, the ribs anterior to that articulating directly with the centrum. On the eleventh, or first caudal vertebra, the parapophyses turn abruptly downward and unite a short distance below the centrum, thus making a sharp distinction between the thoracic and caudal regions. In *Caulolatilus* the parapophyses do not begin until the fifth vertebra, uniting on the thirteenth and in a manner slightly different from that in *Lopholatilus*. In *Latilus* there is a short pedicel on the second vertebra, the parapophyses beginning definitely on the third, the eleventh being the first caudal. The manner in which the parapophyses are united on this vertebra is at once peculiar and characteristic: A branch is sent backward, downward, and inward from the posterior edge of the parapophysis of each side, and this unites with its fellow to separate definitely the thoracic and caudal regions. In *Malacanthus*, the parapophyses of the eleventh, or first caudal, bow widely apart and are united only at their tips, where they reach the interhæmals or inferior axonosts. This occurs to a lesser extent with the twelfth and thirteenth vertebræ, and as a result the body cavity is prolonged into the caudal region, thus making a great distinction in this respect between *Malacanthus* and the other genera under consideration. It is of interest to note that the epipleural is attached to the eleventh vertebra directly in line with the vertebræ immediately preceding it.



Cranium of *Lopholatilus*, superior aspect.

The scapular arch presents no peculiarities in any of the fishes in question, and that of *Lopholatilus* may be taken as typical of all. This has a post-temporal of the usual modified V-pattern, articulating with a simple postero-temporal which in turn joins the proscapula. The post-clavicle is formed of two bones; the actinosts are four in number, gradually increasing in length from above downward, the lowermost being moderately long.

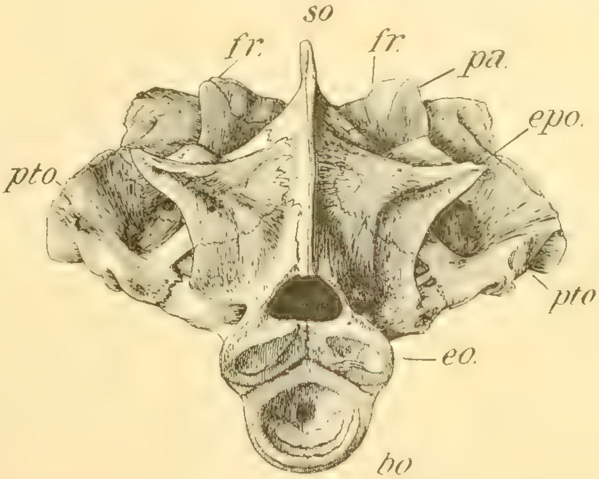
In cranial characters the genera *Latilus*, *Lopholatilus*, and *Caulolatilus* agree with each other and differ from *Malacanthus* in having the skull moderately elevated and the supraoccipital extended forward between the frontals and produced backward between the exoccipitals to the foramen magnum. Furthermore, the thoracic region is sharply marked off from the caudal, while in *Malacanthus* it is, as it were, continued into the caudal portion of the vertebral column.



Cranium of *Lopholatilus*, left lateral aspect.

It would therefore seem best to separate *Malacanthus* from the three other genera and consider them as forming the family *Latilidæ*, as proposed by Doctor Gill.

A still more marked difference exists between *Latilus* and its allies and *Bathymaster* in the fact that the latter does not possess a myodome and also lacks the basisphenoid. The skull of *Bathymaster* is smooth, depressed, and has a small supraoccipital shut out from the foramen magnum; the vertebral column comprises 14 thoracic and 38 caudal vertebræ besides a semivertebra, this being double the number found in any of the Latilidæ. The arrangement of the parapophyses in *Bathymaster* is also quite different from that in the other genera; there is a closed canal beneath the eleventh to sixteenth thoracic vertebræ, formed by the inward extension of a process from the parapophysis of either side, so that these are united below the centra. *Bathymaster* furthermore presents a peculiarity in the shoulder girdle, having the hypocoracoid prolonged beneath and in contact with the fourth, or lowest actinost, while in the



Cranium of *Lopholatilus*, posterior aspect.

majority of fishes there is a considerable gap between the lowest actinost and the projection of the hypocoracoid. Consequently *Bathymaster* must be considered as quite distinct from any of the other genera herein discussed, entitled to the rank of a family, and only distantly related to the Latilidæ.

---

*Explanation of figures.*

*bas*, basisphenoid.
*bo*, basioccipital.
*eo*, exoccipital.
*epo*, epiotic.
*eth*, ethmoid.
*fr*, frontal.
*opo*, opisthotic.
*pa*, parietal.
*pas*, parasphenoid.
*prf*, prefrontal.
*pro* prootic.
*ptf*, postfrontal.
*pto*, pterotic.
*so*, supraoccipital.
*vo*, vomer.

CONTRIBUTIONS FROM THE BIOLOGICAL LABORATORY OF THE BUREAU OF FISHERIES
AT WOODS HOLE, MASS.

# THE BLOOD-VASCULAR SYSTEM OF THE TILE-FISH, LOPHOLATILUS CHAMÆLEONTICEPS.

By C. F. SILVESTER,
*Curator of the Morphological Museum and Assistant in Anatomy, Princeton University.*

# CONTENTS.

Page.
Introduction ..... 89
The heart ..... 89-90
The arteries ..... 90-106
  Ventral aorta and afferent branchial arteries ..... 90
  Efferent branchial arteries ..... 90
    Arrangement of the branchial vessels on the gill arches ..... 91
      The efferent vessels ..... 91
      The afferent vessels ..... 92
  Branches of the efferent branchial arteries ..... 92
    The first efferent branchial artery ..... 92
      The afferent pseudobranchial vessels ..... 94
      The efferent pseudobranchial vessel ..... 95
      The carotid arteries and their branches ..... 96
    The second efferent branchial artery ..... 100
    The third efferent branchial artery ..... 100
    The fourth efferent branchial artery ..... 102
    Dorsal aorta and its branches ..... 102
    The cœliacomesenteric artery ..... 103
    The subclavian arteries ..... 104
    The parietal arteries and their branches ..... 105
The veins ..... 106-109
   I. Hepatic portal system ..... 107
  II. Veins opening into the sinus venosus ..... 107
  III. Veins opening into the Cuvierian ducts ..... 107
  VI. The caudal vein and venae advehentes renales ..... 108
References to figures ..... 109
Literature ..... 112

CONTRIBUTIONS FROM THE BIOLOGICAL LABORATORY OF THE BUREAU OF FISHERIES
AT WOODS HOLE, MASS.

# THE BLOOD-VASCULAR SYSTEM OF THE TILE-FISH, LOPHOLATILUS CHAMÆLEONTICEPS.

By C. F. SILVESTER,
*Curator of the Morphological Museum and Assistant in Anatomy, Princeton University.*

## INTRODUCTION.

In the following pages an effort has been made to present a fairly complete list as well as description of the blood vessels of *Lopholatilus chamæleonticeps*, with the hope that the results may serve as a basis for comparison with the blood vessels of other teleosts. Fifteen tile-fish were dissected, 11 for the arterial and 4 for the venous system. For purposes of comparison the arterial systems of 20 other teleosts also were examined, and many of them are figured in the present paper.

Since it has frequently been found difficult successfully to inject the blood vessels of teleosts, the method adopted by the writer, which has proved most satisfactory, may be mentioned: The best French gelatin, after being soaked for from five to ten hours in cold water, is rinsed and drained for a short time in order to get rid of the excess of water, then heated, and a 20 per cent glycerin solution stirred in until the whole possesses the consistency of cream. The coloring mass, either vermilion or insoluble Prussian blue, is then added. The arteries are usually injected from a branch of the cœliacomesenteric, the veins from one of the tributaries of the portal vein and the genital or caudal vein. In order to make a successful injection the specimen must be cold and the injection mass heated to about 39° C., or even warmer. After the injection the specimen should be plunged into cold water to facilitate the hardening of the gelatin. Injected specimens are preserved, as a rule, in a 5 per cent formalin solution.

The material for the subject under consideration was collected under the auspices of the United States Fish Commission at Woods Hole, Massachusetts, and I take this opportunity of expressing my thanks to Dr. H. C. Bumpus and Dr. H. M. Smith for their kind assistance in connection with this portion of the work. It is with pleasure that I acknowledge also my deep indebtedness to Prof. C. F. W. McClure for much valuable assistance throughout the research.

## THE HEART.

The heart of *Lopholatilus chamæleonticeps* is similar in position and form to that of many other teleosts. It lies in the pericardial cavity between the two clavicles, just dorsal to the basipterygium and ventral to the œsophagus and first two or three vertebræ. Its chambers consist of a sinus venosus, an auricle, and a ventricle. The sinus is a transversely placed, thin-walled, tubular chamber, into which the Cuvierian ducts empty, and communicates with the auricle by the large sinu-auricular opening, which is guarded by a two-lipped valve. The auricle is large, thin-walled, and situated cranial to the sinus and slightly cranial and dorsal to the ventricle. Its lateral angles project somewhat ventrad upon the sides of the bulbus arteriosus, and it opens into the ventricle by the auriculoventricular aperture, which is a transverse, elliptical opening with a two-lipped valve. The ventricle is thick-walled, and shaped like a triangular pyramid with the apex directed caudad. The bulbus arteriosus, which is quite large, extends craniad from the base or cranial portion of the ventricle, and tapers into the ventral aorta. The valve between the ventricle and bulbus consists of two segments and is of the usual semilunar type. According to Boas (1880), the small region between the bulbus and ventricle, in which the valve is situated, corresponds to the conus arteriosus of the elasmobranch heart.

## THE ARTERIES.

### THE VENTRAL AORTA AND THE AFFERENT BRANCHIAL ARTERIES.

The ventral aorta (figs. 16 and 18, pl. I) extends craniad as a continuation of the bulbus arteriosus, and after giving off, in the order named, the fourth, third, and second pairs of afferent branchial arteries, bifurcates at its cranial end to form the first pair of afferent vessels. On each side the third and fourth afferent branchial arteries arise from a common stem. The second pair arise as separate vessels.

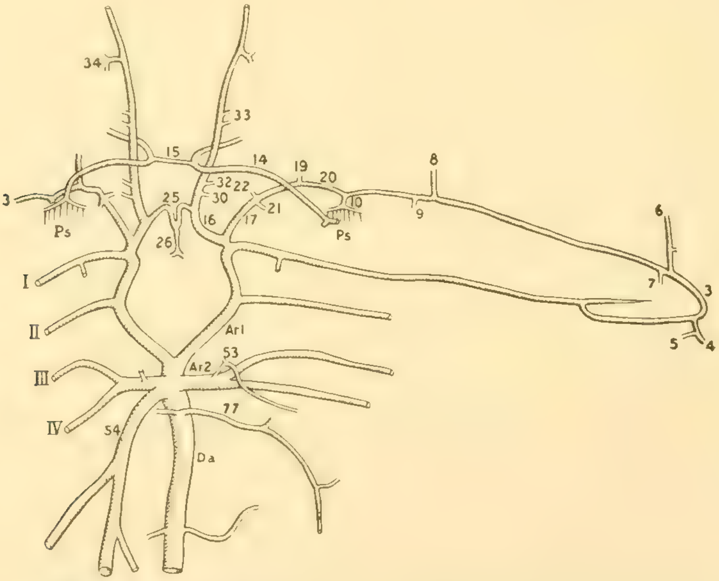


FIG. 1.—Efferent branchial vessels of tile-fish (*Lopholatilus chamæleonticeps*), with circulus cephalicus. Ventral aspect, natural size. On the left side the hyoidean and afferent pseudobranchial arteries are shown; on the right side the efferent pseudobranchial artery.

### THE EFFERENT BRANCHIAL ARTERIES.

The efferent branchial arteries (I to IV, figs. 16 and 18, pl. I) correspond pair for pair with the afferent vessels just described. They converge, one from each gill arch, and run mesad; the first and second pairs unite to form the first aortic root (fig. 4, *Ar. 1*), while the third and fourth similarly unite to form the second (*Ar. 2*). The aortic roots of each side unite in the median line, ventral to the first vertebra, to form the dorsal aorta. The posterior arc of the circulus cephalicus is formed on the base of the skull by the proximal portion of the first pair of efferent branchial arteries and the first pair of aortic roots. In front the circulus is completed by the union of the internal carotids.

Ridewood (1899) has classified the circulus cephalicus of teleosts into four groups, A, B, C, and D, on the basis of the relationships held by the efferent branchial arteries to the circulus and the dorsal aorta. The groups A, B, and D are represented by *Pomolobus* (fig. 3), *Leptocephalus* (fig. 2) and *Microgadus* (fig. 9), respectively. The tile-fish would fall under group C, since the first and second efferent branchial arteries open into the circulus cephalicus and the third and fourth open into the aorta immediately behind the circulus (fig. 1).

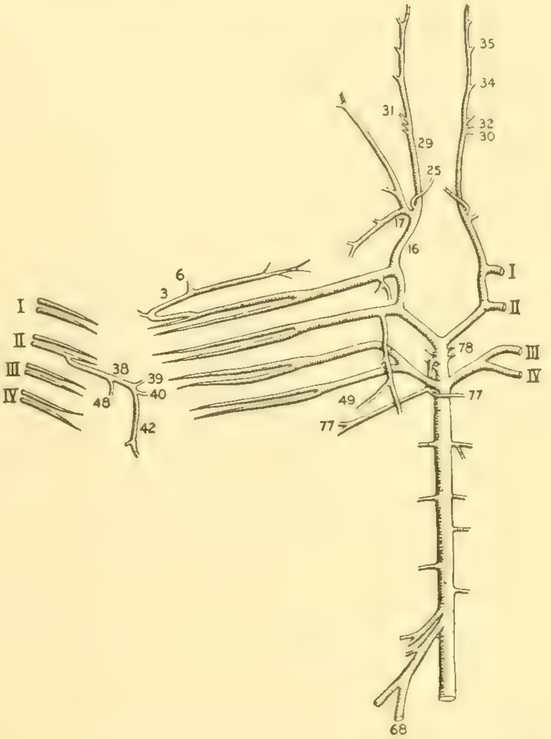


FIG. 2.—Efferent branchial and head arteries, with circulus cephalicus, in the conger eel (*Leptocephalus conger*). Ventral aspect natural size. On the right side the efferent branchial vessels are shown reflected so as to bring them into one plane. The ventral ends of the left efferent branchial arteries are drawn to show their relation to those of the opposite side.

## ARRANGEMENT OF THE BRANCHIAL VESSELS ON THE GILL ARCHES.

*The efferent vessels.*—The efferent branchial arteries are usually split for some distance at their ventral ends (fig. 12), the two branches lying one on each side of the afferent trunk. For the most part the efferent filamentar arteries open directly into the efferent trunk; the most dorsally situated, however, communicate with it by means of two collecting vessels (*2*, figs. 5 and 18), one from each hemibranch. (In a specimen 50 cm. long, these collecting vessels measured 1 to 3 cm. in length.) So far as known to the writer, the efferent branchial vessels of teleosts have been described as single, one vessel on each holobranch and the two series of filamentar vessels opening into it. Parker (1886, p. 689) states as follows regarding the efferent branchial vessels: "In *Holocephali* and *Teleostei* there is only one efferent artery to each gill, corresponding to the anterior of the two efferent arteries in the plagiostome holobranch." The writer finds, however, in a large number of teleosts in addition to the tile-fish, indications of two efferent branchial arteries on a single arch. In some instances these vessels are double for almost the entire length of the arch, as in the case of the conger eel (*Leptocephalus*, fig. 2), thus resembling in many respects the corresponding vessels in *Ceratodus*, described by Spencer (1893).

*The afferent vessels* (fig. 18, pl. I). The afferent branchial arteries, as a rule, run some distance on the gill arches before branching to the gill filaments. At a point where the split ends of the efferent arteries join to form a single vessel, the afferent artery gives off a recurrent branch (*1*, fig. 18) which runs between the two efferent vessels and branches to the most ventrally situated gill filaments. Beyond this point the afferent vessel occupies a position lateral to the efferent trunk.

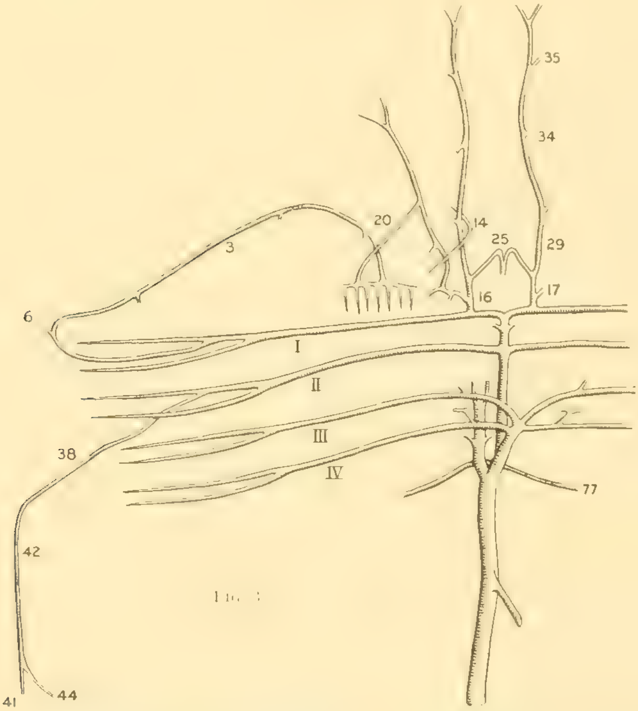


Fig. 3

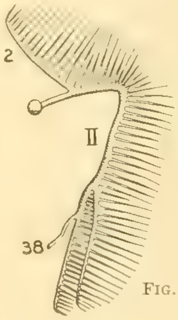


Fig. 4

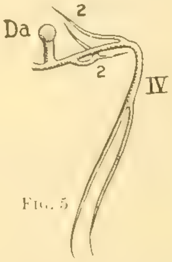


Fig. 5

Fig. 3.—Cranial portion of the arterial system in the hickory shad (*Pomolobus mediocris*). Ventral aspect, natural size. The efferent branchial arteries have their ventral ends reflected on the right side and cut off short on the left.

Fig. 4.—Second efferent branchial artery in the hickory shad, viewed from front, showing arrangement of efferent vessels. Natural size.

Fig. 5.—Fourth efferent branchial artery in the hickory shad, viewed from front, showing arrangement of efferent vessels on arch: filamentar vessels not shown.

### BRANCHES OF THE EFFERENT BRANCHIAL ARTERIES.

*The first efferent branchial artery* (I, fig. 16, pl. I). This artery gives off the following branches, which will be described in the order named: A. The hyoidean artery. B. The direct afferent pseudobranchial artery. C. A small vessel which lies dorsal to the gills. D. The carotid artery.

A. The *hyoidean artery* (*3*)[a] arises about 2 cm. from the ventral end of the first branchial arch, and pursues a course chiefly following the hyoid arch ultimately to reach the pseudobranch. Passing mesocraniad along the first branchial arch, it curves laterad through a foramen situated in the lower (ventral) end of the ceratohyal near its dorsal border, continues along the lateral or cranial surface of the ceratohyal and interhyal and passes through a fissure between the caudal angle of the quadrate and the dorsal end of the symplectic, still occupying a position lateral to the bones; then passes dorsad through a fissure between the ventral end of the hyo-mandibular and the metapterygoid and continues dorsad along the inner surface of this bone until it reaches the pseudobranch[a].

---

[a] The hyoidean artery has been described by former writers under a number of different names, such as *A. hyoideo-opercularis* (Müller, 1839), *A. hyo-opercularis* (Owen, 1866), *A. hyo-mandibularis* (Maurer, 1888).

The following are its branches:

a. A vessel at the ventral end of the first branchial arch which divides into the nutrient artery to this arch (*5*, fig. 16) and into branches which go to the cranial part of the musculus sternohyoideus.[b] (*4*, fig. 16.)

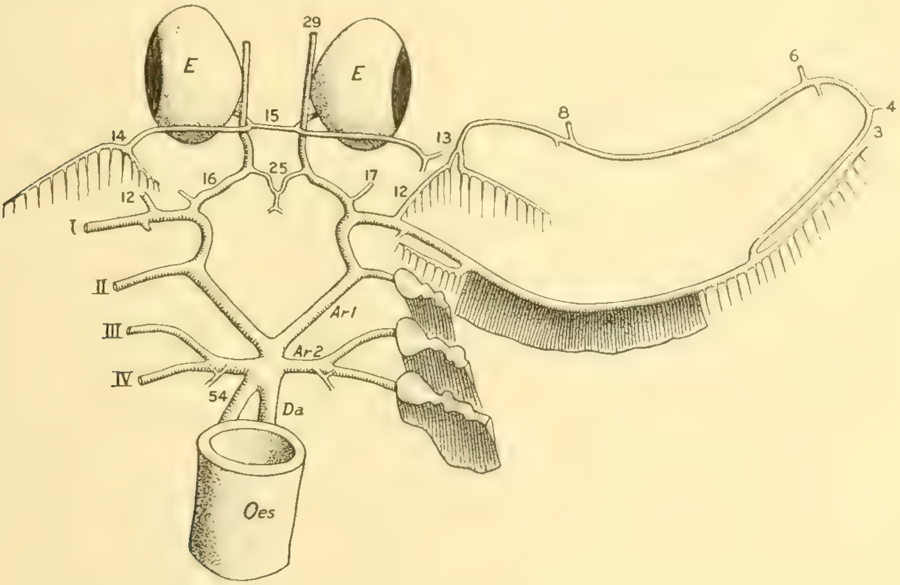


FIG. 6.—Efferent branchial vessels of tile-fish, with circulus cephalicus. Ventral aspect, natural size. On the left side the hyoidean and direct afferent pseudobranchial arteries are shown; on the right side the efferent pseudobranchial artery.

b. An anterior and a posterior branch shortly after passing through the foramen at the ventral end of the ceratohyal. The anterior branch (*6*) corresponds to the lingual artery of Wright (1885) and supplies the musculus geniohyoideus and structures on the floor of the mouth; it terminates in two vessels which accompany the rami of the dental bone. The posterior branch (*7*) is somewhat smaller than the anterior and runs caudad over the lateral surface of the ceratohyal to supply the branchiostegal region.

c. Two branches where the artery passes through the fissure between the quadrate and symplectic; the larger/anterior branch (*8*) runs craniad and divides into several branches which supply the greater part of the musculus adductor mandibulæ; the posterior branch (*9*) runs ventrad and caudad, spreading out on the inner side of the infra- and subopercular.

---

[a] The pseudobranch of the tile-fish consists of from 40 to 50 filaments, and occupies a position on the medial side of the dorsal end of the hyomandibular; its filaments are parallel to the most dorsally situated filaments of the first gill.

[b] For the muscular system the writer has followed the terminology of Allis (1897), and for the bones that of Reynolds (1897) and Parker & Haswell (1897).

*The afferent pseudobranchial vessels* (figs. 1 and 6). Before entering the pseudobranch the hyoidean artery usually anastomoses with or is joined by one of two arteries. The ordinary arrangement (fig. 1) is that where the hyoidean artery is joined by a branch (*20*) of the a. hyoöpercularis (*17*) and then enters the pseudobranch at its ventromedial angle to spread out over the surface which adjoins the hyomandibular bone. In the second arrangement (fig. 6) the hyoidean artery is joined, by means of a connecting branch (*13*), with a vessel which might be called the direct afferent pseudobranchial artery (*12*).

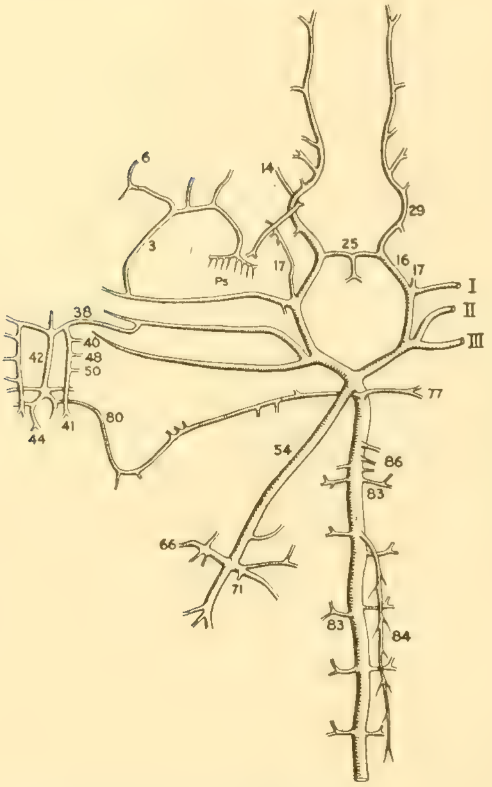


FIG. 7.—Cranial portion of the arterial system in the swell-fish (*Spheroides maculatus*). Ventral view, natural size. On the right side the ventral ends of the efferent branchial arteries and their branches are reflected so as to bring them into one plane.

B. *The direct afferent pseudobranchial artery* (*12*) was present in only two of the nine specimens dissected, and only on one side. It was given off from the first efferent branchial artery just lateral to the carotid, and supplied the medial half of the pseudobranch. It also anastomosed with the hyoidean artery, and in this case the latter supplied the lateral portion of the pseudobranch. This arrangement resembles that found in *Gadus*, as described by Müller (1839), where the pseudobranch receives its blood from the hyoidean artery and from a branch which comes directly from the circulus cephalicus. The former condition, which is the one more generally met with among teleosts, resembles that described by Müller for *Sander* (*Lucioperca*), in which the pseudobranch receives blood from the hyoidean and hyoöpercular arteries.

There appears to be considerable variation among the teleosts with regard to the blood supply to the pseudobranch. Aside from the two methods described above for the tile-fish, the pseudobranch of teleosts in general receives its blood (a) entirely from the circulus cephalicus (pike, according to Maurer, 1888); (b) entirely by the hyoidean artery (*Spheroides*, fig. 7); or (c) by all three vessels—i. e., the hyoidean artery, a branch of the a. hyoöpercularis, and the direct afferent pseudobranchial artery (*Myoxocephalus*, fig. 8). In teleosts where the pseudobranch is wanting, the dorsal portion of the hyoidean artery is reduced in size, as in *Leptocephalus* (fig. 2), where it terminates in branches which supply the branchiostegal region and membranes at the dorsal end of the ceratohyal.

*The efferent pseudobranchial vessel* (fig. 16, pl. I, and figs. 1 and 6). The efferent pseudobranchial or ophthalmic artery (*14*), arising from the caudal or exposed surface of the pseudobranch, leaves the latter at its ventromedial angle, and runs slightly craniad and mesad, piercing the m. adductor hyomandibularis; thence it continues dorsad to a point just cranial and ventral to the origin of the recti eye muscles, where it sends off a stout branch (*15*) which anastomoses with its fellow of the opposite side

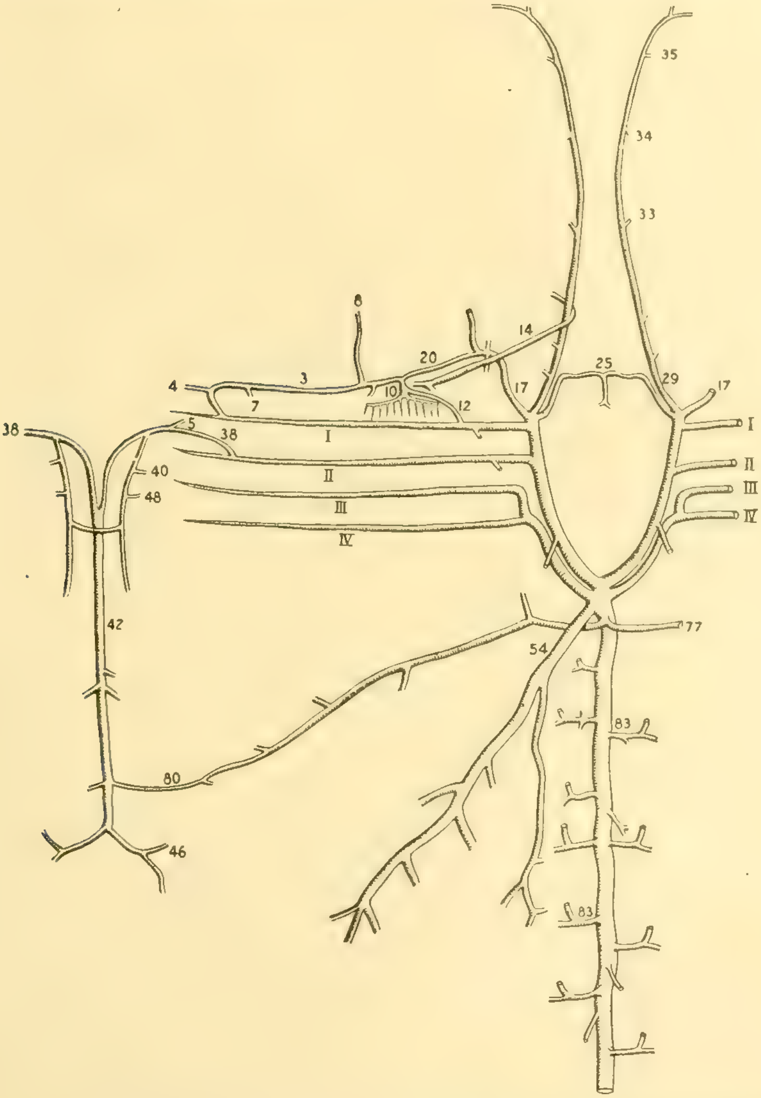


FIG. 8.—Cranial portion of the arterial system in the sculpin (*Myoxocephalus octodecimspinosus*). Ventral view, natural size. On the right side the ventral ends of the efferent branchial arteries and their branches are reflected so as to bring them into one plane.

directly dorsal to the parasphenoid. From this point it continues dorsad and craniad between the rectus inferior and rectus posterior and pierces the sclerotic at the lower edge of the optic nerve. Within the eye it forms an anastomosis known as the "choroid gland."

According to Maurer the hyoidean artery represents in teleosts the most anterior of the six aortic arches, or the mandibular aortic arch. He states that in the trout embryo two vessels are developed in connection with the hyoid arch, one of which is situated in front of and the other behind the cartilage. The former is regarded by him as equivalent to the mandibular aortic arch, the latter as equivalent to the hyoidean aortic arch. Since the vessel in front of the cartilage alone persists in the adult, becoming the hyoidean artery, it is the homologue of the mandibular aortic arch. Both of these vessels are originally connected with the anterior end of the ventral aorta, their connection with the first efferent branchial artery, which is characteristic of the adult, being a secondary one (Maurer, 1888). Allis (1901) also seems to regard the hyoidean artery as belonging to the mandibular rather than the hyoid arch. He says (op. cit., pp. 115–116), "This postero-ventral prolongation of the efferent pseudobranchial artery of 12 mm. larvæ of *Amia* thus has, in its dorsal portion, the same relation to the cartilage of the palato-quadrate arch that the branchial arteries have to the cartilages of their respective arches. * * * In its ventral portion this artery acquires relations to the hyoid arch, but it there lies anterior to the cartilage of the arch and not posterior to it. * * * It thus has a position it could naturally acquire by simply slipping backward off the hind edge of the mandibular cartilages. * * * In both its ventral and dorsal positions this artery seems to correspond closely, in general position, to the artery usually described in teleosts as the arteria hyoidea."

Wright (1885) regards the hyoidean artery as representing simply the enlarged nutritive branch to the hyoid arch. He says (op. cit., p. 486): "The condition of the parts in *Lepidosteus* proves that the arteria hyoidea of the teleosts is not the homologue of the hyoidean aortic arch, as is sometimes assumed, for the two vessels coexist in the genus. * * * It appears to me to be homodynamous with the nutritive or branchial arteries which spring from the succeeding efferent arteries, in the way this does from the first, and to owe its greater relative size in ganoids and teleosts to the development of the gill cover from the hyoid arch."

Owen (1866) and others, however, regard the hyoidean artery as equivalent to the hyoidean aortic arch. From the conditions found in the adult teleost, the writer can see no reason for assigning it to the mandibular rather than to the hyoid arch. It seems perfectly natural to regard it as belonging to the latter, and as representing the more cranial of the two efferent vessels which are present on each branchial arch in sharks and rays.

C. *The next branch of the first efferent branchial artery is a small vessel* (*11*) which arises near the dorsal end of the first gill, and, passing caudad, dorsal to the second and ventral to the third branchial artery, supplies the muscles and membranes at the dorsal ends of the gill arches.

D. *The carotid arteries and their branches* (fig. 16, pl. I). The carotid artery (*16*) is given off at the angle where the first efferent branchial artery bends caudad to join the second. Almost immediately beyond its origin it sends off a large branch, which extends dorsad, craniad, and laterad. This vessel (*17*), the "muscular branch" of many writers, has been called by Allis (1897), in his description of *Amia*, the a. hyoöpercularis. About 1 cm. from its point of origin the a. hyoöpercularis (*17*) passes through the facial foramen and then divides into three main branches.

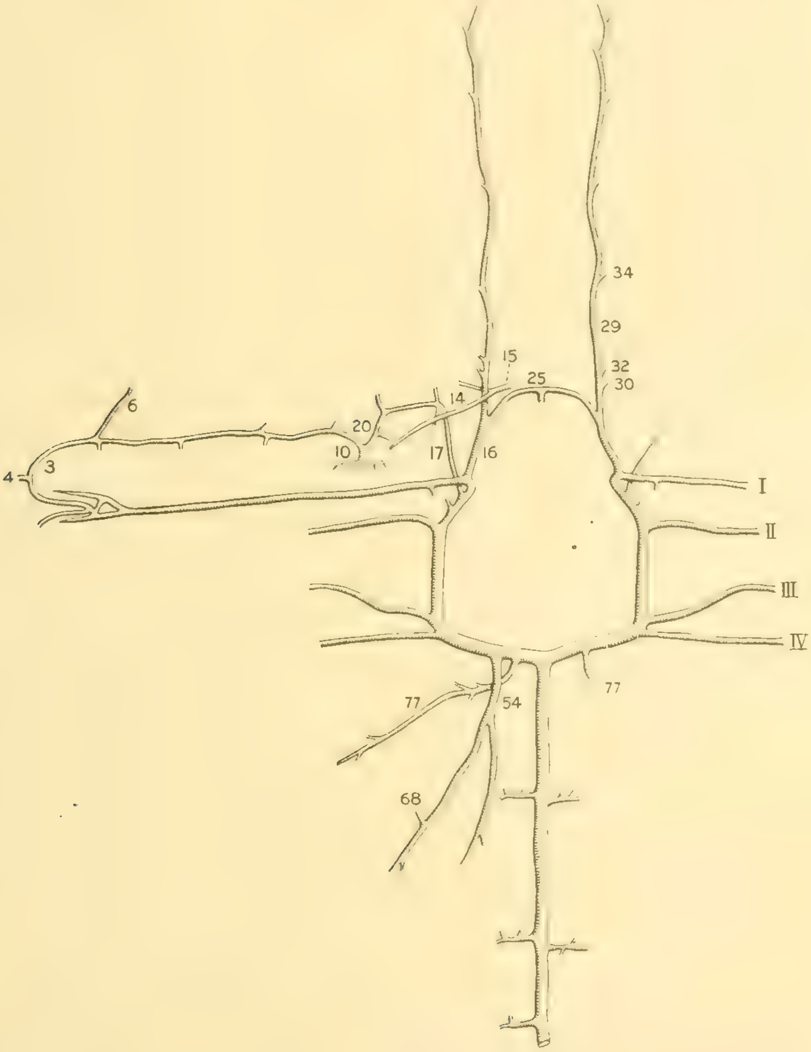


FIG. 9.—Cranial portion of arterial system in the tomcod (*Microgadus tomcod*). Ventral aspect, ×2. The first efferent branchial and hyoidean arteries of the right side are reflected so as to bring them into one plane.

The largest of these three branches runs craniad and ventrad below the orbit for about 1 cm., sends a small branch to the m. adductor hyomandibularis, and then divides into two branches; the larger (*19*) runs craniad and supplies the inner or deep division of the m. adductor mandibulæ; the smaller (*20*) running ventrad and slightly laterad for about 18 mm., in a groove which crosses the metapterygoid, joins the hyoidean artery, and, in common with the latter, supplies the pseudobranch as described above. In the two cases where the direct afferent pseudobranchial artery was found to be present, this latter branch was small and did not join the hyoidean artery.

The second division of the a. hyoöpercularis (*21*), running caudad and ventrad just medial to the upper end of the hyomandibular, sends a small branch to the m. adductor hyomandibularis, and supplies the mm. adductor and levator operculi.

The remaining or third branch of the a. hyoöpercularis (*22*) divides into a supraorbital and a postorbital branch. The supraorbital branch (*23*) runs craniad on the dorsal wall of the orbit; the postorbital branch (*24*) supplies the m. levator arcus palatini and membranes behind the orbit. According to Allis (1901) the a. hyoöpercularis in *Amia* represents the dorsal portion of the hyoidean aortic arch.

In the teleosts this vessel may arise in three different ways: From the first efferent branchial artery, as in *Microgadus* (fig. 9); from the junction of the first efferent branchial artery with the carotid, as in *Opsanus* and *Spheroides* (figs. 10 and 7); and from the common carotid, as in the tile-fish.

After giving off the a. hyoopercularis, the carotid continues craniad for a short distance, pierces the skull wall between the parasphenoid and proötic, and immediately divides into the internal and external carotid arteries.

*The external carotid artery and its branches* (fig. 16, pl. I). (a) Two small branches are given off from the external carotid near its origin. The larger (*30*) runs laterad and divides into two branches which supply the external and superior recti muscles of the eye. The artery that supplies the latter muscle runs along its inferior border and pierces the sclerotic to enter the eye (*31*). The other branch is a small vessel (*32*) which supplies the inferior and internal recti muscles of the eye. These two arteries frequently arise by a single trunk from the external carotid.

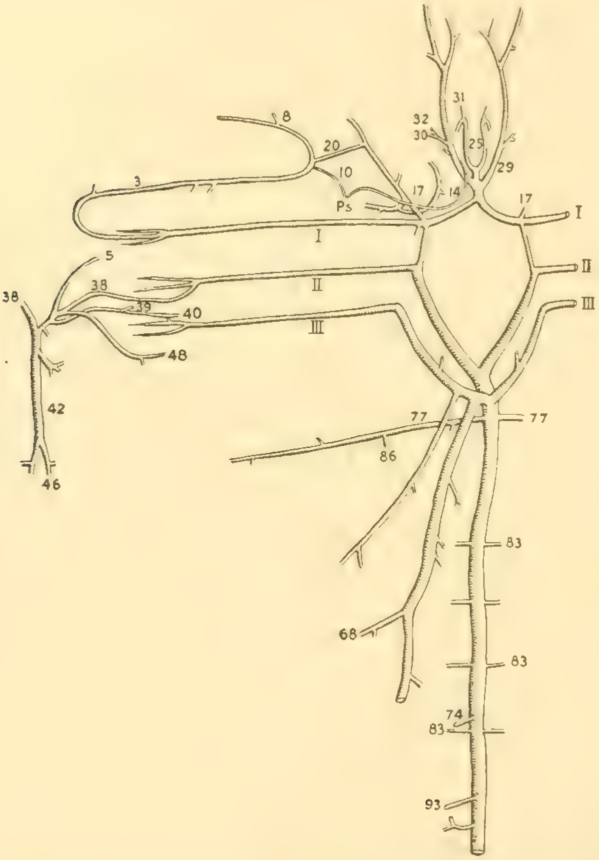


FIG. 10.—Cranial portion of the arterial system in the toad-fish (*Opsanus tau*). Ventral view, natural size. On the right side the ventral ends of the efferent branchial arteries and their branches are reflected so as to bring them into one plane.

(b) Beyond the point of origin of the arteries supplying the recti muscles, the external carotid artery lies close to the eyeball and in this position gives off two small branches (*33*) to the membranes lining the orbit. It then curves slightly dorsolaterad and, passing between the oblique muscles of the eyeball, gives off a small branch (*34*) which divides to each of these two muscles and to the mucous lining of the orbit. The main trunk continues craniad and, passing through a foramen in the prefrontal bone, occupies a position just ventral to the olfactory organ, which it supplies by means of one or two small branches (*35*). At this point, also, a branch (*36*) runs ventrocraniad to supply the maxilla, the roof of the mouth, and the maxillary breathing valve (Dahlgren, 1898). The direct continuation of the main artery extends craniad ventral to the nasal bones, where it gives off small branches to the upper lip and membranes of this region, and finally pierces the premaxilla as the superior dental artery (*37*).

*The internal carotid artery and its branches* (fig. 16, pl. I). The internal carotid artery (*25*) runs mesad and slightly craniad until it reaches the median line, then dorsad for a short distance, accompanied by the internal carotid of the opposite side, with which it anastomoses to form a single median vessel, the carotis interna impar (*26*). The latter continues dorsad, passing through a median foramen in the basisphenoid, and on the ventral surface of the hypophysis divides into two pairs of vessels, the anterior and posterior cerebral arteries.

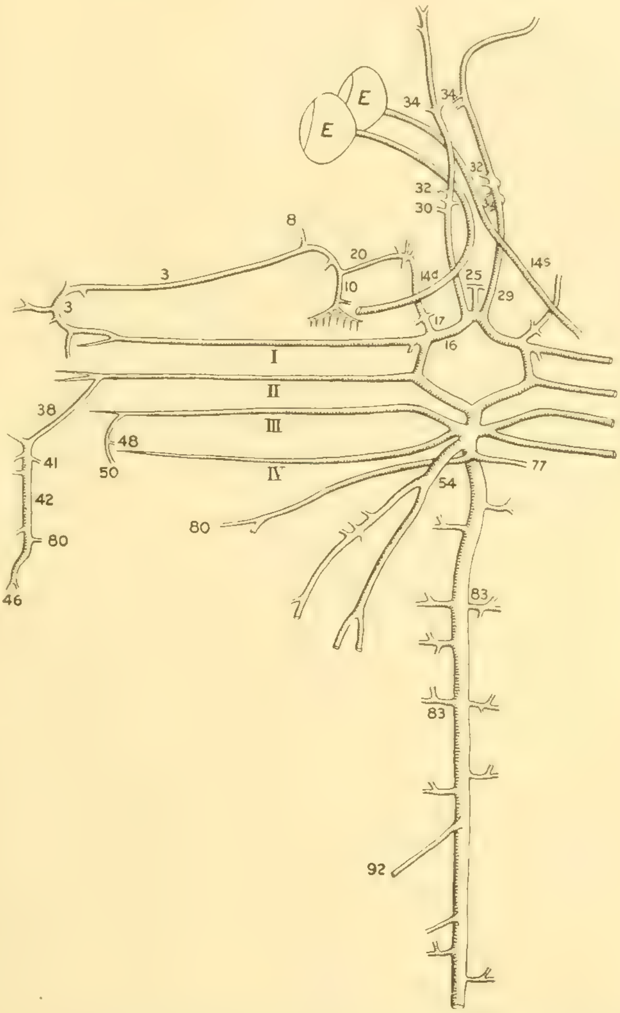


FIG. 11.—Cranial portion of the arterial system in the flounder (*Limanda ferruginea*). Ventral aspect, natural size. On the right side the ventral ends of the efferent branchial arteries and their branches are reflected so as to bring them into one plane.

The anterior cerebral arteries run craniad, side by side, to supply the telencephalon. The posterior vessels curve laterad and caudad over the lobi inferiores to join again in the median line on the ventral surface of the medulla near its cranial end. At this point they give off anterior and posterior branches, the former supplying the greater portion of the brain, while the latter run caudad, on the ventral surface of the medulla, to reach the spinal cord. On the sides of the lobi inferiors the posterior cerebral arteries usually give off several small branches, one or two of which supply the ear.

In some teleosts (*Opsanus* and *Limanda*, figs. 10 and 11) the internal carotids join near their points of origin to form an arteria carotis interna impar; in others (*Leptocephalus*, fig. 2) union does not take place until they reach the base of the brain. The position and constant occurrence of the arteria carotis impar of teleosts suggests its homology with the cranial end of the primitive dorsal aorta (Ayres, 1889) of the lower elasmobranchs.

*The second efferent branchial artery* (fig. 16, pl. I, and fig. 12). About 2 cm. from its ventral end the second efferent branchial artery (II) gives off a large branch (*38*) corresponding to the fourth[a] commissural artery of *Amia* as described by Parker and Davis (1899). This vessel (*38*) runs toward the median line and joins its fellow of the opposite side at a point ventral to the thyroid gland and ventral aorta, forming the median hypobranchial artery (*42*), which runs caudad, passing below the ventral ends of the clavicles, and terminates in branches which supply the ventral fins.

The fourth commissural artery gives off three small branches, namely, two nutrient arteries, one to the second (*39*) and one to the third (*40*) branchial arch, and a ventral coronary artery (*41*), which is given off near the median line or, in some cases, from the median hypobranchial artery itself, which runs caudad on the ventral aorta and, in combination with a coronary artery that usually arises from the fifth commissural artery, supplies the bulbus arteriosus and the heart.

The median hypobranchial artery divides into the thyroid artery (*43*), which immediately enters the thyroid gland; two small branches (*44*) which supply part of the m. sternohyoideus; and finally a branch (*45*) which supplies the muscles attached to the clavicles. Opposite the cranial end of the basipterygium the coracoid artery (*80*) anastomoses, by means of a small branch, with the median hypobranchial, which terminates (*46*) in the ventral fin. Since the coracoid artery is a branch of the subclavian, it will be described in connection with that artery. In teleosts where the ventral fins are wanting (*Leptocephalus* and *Spheroides*, figs. 2 and 7), or where they are situated far back on the abdomen (*Pomolobus*[b], fig. 3), the median hypobranchial artery is somewhat reduced in size and terminates in the m. sternohyoideus. Parker and Davis (1899) have described it as dividing into coronary and epigastric branches, but in many teleosts this description will not hold, for the coronary may be a branch of the commissural artery. For this reason the entire median vessel formed by the joining of the commissural arteries is designated in this paper as the median hypobranchial artery.

*The third efferent branchial artery* (fig. 16, pl. I, and fig. 12). Like the second of the series, the third efferent branchial artery usually has but one branch, which corresponds to the fifth commissural artery of Parker and Davis. This branch (*47*) arises about 2 cm. from the ventral end of the artery and runs toward the median line, where it may join the corresponding artery of the opposite side to form a single vessel—the dorsal median hypobranchial artery (*52*). As a rule, however, it does not reach the median line, but curves caudad dorsal to the fourth division of the musculus obliquus ventralis, and terminates, like the dorsal median hypobranchial, in the musculus constrictor pharyngis and inferior pharyngeal teeth. The branches of the fifth commissural artery are the dorsal coronary artery (*49*), which is given off from either the right or left side, and two pairs of nutrient branches which go to the fourth (*48*) and to the rudimentary fifth (*50*) branchial arch. In one case the vessel which supplied the rudimentary fifth arch was joined by a branch (*51*, fig. 12) from the left fourth efferent branchial artery; also, in one individual the fifth commissural artery was wanting, its place being taken by the sixth, which was present only on one side and arose from the fourth efferent branchial vessel.

---

[a] Parker and Davis in numbering the visceral arches followed the scheme laid down by Gegenbauer (1898), in which the first visceral arch is represented by the upper and lower jaws, the second by the hyoid arch, the third by the first branchial arch, etc.

[b] In *Pomolobus* the ventral fins are supplied by a pair of somewhat larger peritoneal branches.

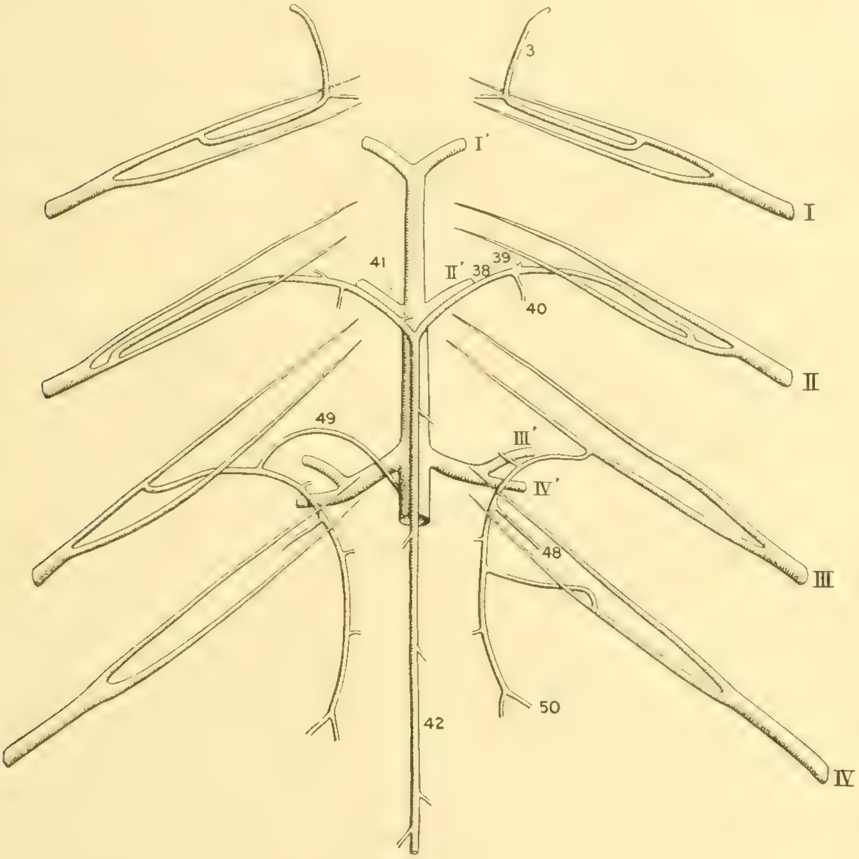


FIG. 12.—Ventral ends of the efferent branchial vessels and their branches in the tile-fish. Ventral aspect, ×2.

Summing up the arrangement of these vessels in the tile-fish, it will be seen that the species possesses dorsal as well as ventral coronary arteries, a dorsal and ventral median hypobranchial artery, fourth, fifth, and sixth commissural arteries, and indications of a lateral hypobranchial artery.

In individuals of the same species, as well as in species, teleosts show much variation as to the arrangement of their hypobranchial and commissural vessels, all tending to indicate a primitive condition, such as is found in the Elasmobranchii, where the ventral ends of all the efferent branchial arteries of each side are connected by means of a lateral longitudinal vessel—the lateral hypobranchial artery of Parker & Davis—and where vessels (commissural arteries) from these lateral hypobranchial arteries run toward the median line and unite to form the median hypobranchial artery. As Parker & Davis have pointed out, the usual arrangement of these vessels in teleosts is a single pair, the fourth commissural arteries running toward the median line, where they join to form the median hypobranchial artery. Parker (1899 and 1900), however, describes for *Mola* the presence of dorsal as well as ventral coronary arteries, and considers more than one pair of commissural arteries a remarkable condition not likely to be possessed by a teleost. The writer has found lateral hypobranchial arteries, as well as dorsal coronary arteries, in a number of teleosts in addition to *Mola*. In a kingfish (*Menticirrhus*) the ventral ends of the first, second, and third efferent branchial arteries were connected by a lateral hypobranchial, while in a tomcod (*Microgadus*, fig. 13) the ventral ends of all four of the efferent brancial arteries were connected. The third, fourth, and fifth pairs of commissural arteries were also present in this individual.

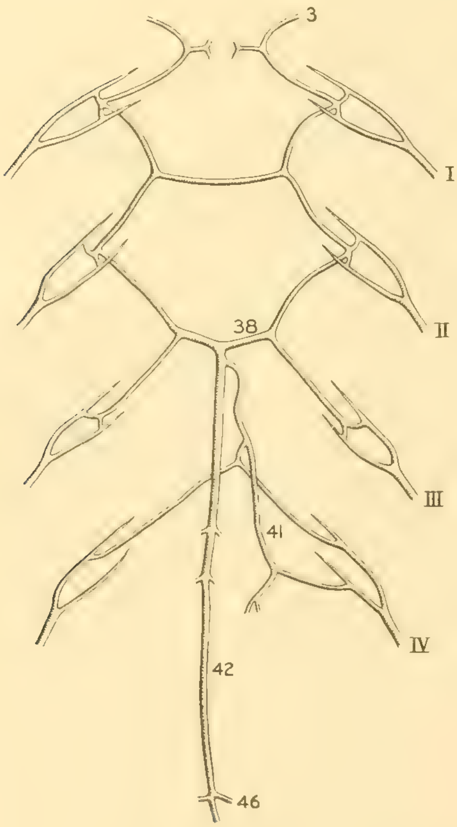


FIG. 13.—Ventral ends of the efferent branchial vessels and their branches in the tomcod. Ventral aspect, × 4.

*The fourth efferent branchial artery* (fig. 16, pl. I, and fig. 12). This artery, which as a rule has no branches, joins the third efferent branchial artery to form the second root of the dorsal aorta. A small artery (*53*) arises from the ventral surface of the second aortic root, and, running ventrad and laterad, divides into branches which supply the sides of the pharynx, superior pharyngeal teeth, and membranes on the rudimentary fifth branchial arch.

## THE DORSAL AORTA AND ITS BRANCHES.

The dorsal aorta (fig. 16, pl. I, and fig. 15) is formed by the junction of the two pairs of aortic roots, and extends caudad along the ventral surface of the vertebral column in a series of undulations which correspond to the topography of the ventral surface of the vertebral column. That portion of the dorsal aorta which runs in the abdominal region lies free, while that in the tail is inclosed by the hæmal arches.

*The cœliacomesenteric artery.* The cœliacomesenteric artery (*54*) is not, strictly speaking, a branch of the dorsal aorta, as it arises in common with the latter and the second right aortic root. It is an artery of considerable size, running caudad and dividing into numerous branches.

The first branch (*55*) arises about 1 cm. from the origin of the artery, runs caudad along the right dorsal surface of the œsophagus and right side of the stomach, and curves upon the ventral surface of the latter, where its main termination runs ventrad and caudad, in the gastrohepatic omentum, as the left hepatic artery (*61*). It gives off the following vessels: (a) Œsophageal branches (*56*) to the right side of the œsophagus; (b) the right ovarian or spermatic artery (*57*), which is given off at the junction of the œsophagus and stomach and runs directly caudad to supply the genital gland; (c) a small branch (*58*) which is given off on the ventral surface of the stomach and crosses the ductus choledochus to the central portion of the liver; (d) several small gastric branches (*59*), which run to the ventral surface of the stomach and proximal portion of the intestine, one or two of them usually anastomosing with a branch (*66*) of the second branch (*62*) of the cœliacomesenteric artery.

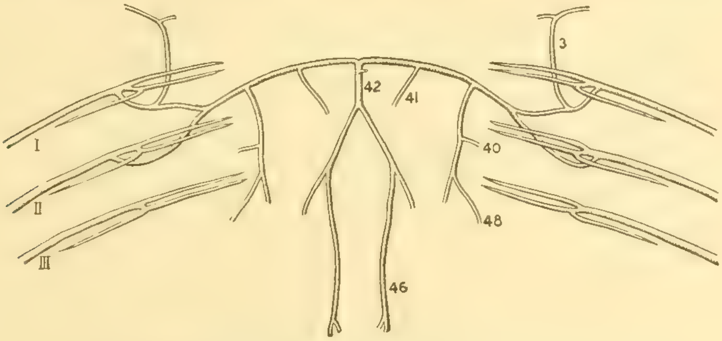


FIG. 14.—Ventral ends of the efferent branchial vessels and their branches in the goose-fish (*Lophius piscatorius*). Ventral aspect, × ¼.

The second branch (*62*) of the cœliacomesenteric artery arises about 1 cm. caudal to the first. It runs caudad on the left dorsal surface of the œsophagus and left side of the stomach, dividing into a left spermatic or ovarian artery (*64*) which runs directly caudad to supply the genital gland of the left side, and into several gastric branches (*65*) which supply the left side of the stomach. As stated above, one or two of these gastric branches usually anastomose on the ventral surface of the stomach with a gastric branch (*60*) of the first branch of the cœliacomesenteric. The anastomosis of these two vessels (*60* and *66*) may form an artery (*67*) which runs in the gastrohepatic omentum close to the left hepatic artery (*61*), supplying a portion of the liver. The second branch of the cœliacomesenteric artery also sends out a small artery (*63*) to the left side of the œsophagus.

The third branch (*68*) of the cœliacomesenteric is a vessel of considerable size, given off about opposite the middle of the stomach, and itself giving off two branches (*69* and *70*), beyond which point it runs caudad to enter the swim-bladder at the ventral surface and to break up into the rete mirabile. As already stated, it has two main branches, which are given off near its origin. The first is a gastric branch (*69*) and supplies a part of the left side of the stomach; the second is the right hepatic artery (*70*) which supplies the gall bladder and right side of the liver.

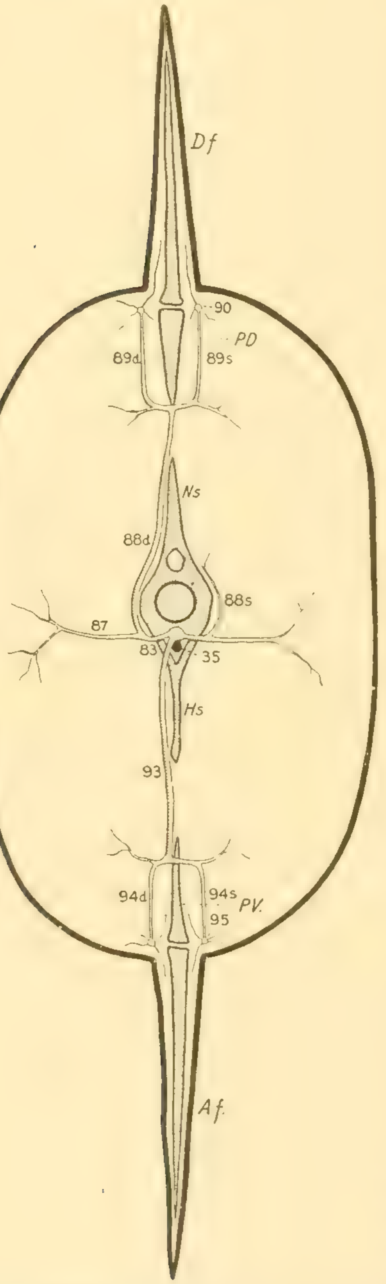


Fig. 15.—Diagrammatic cross section of body of tile-fish in tail region, showing arrangement of parietal arteries. Natural size.

The fourth branch of the cœliacomesenteric artery is the pancreatic artery (*71*). This is a small vessel which is given off about 1 cm. caudal to the third branch and almost immediately enters the pancreas.

Beyond its fourth branch the cœliacomesenteric artery continues caudad, passing to the right of the stomach to divide, at a point just cranial to the spleen, into four branches (*72*, *74*, *75*, *76*). The first branch, or gastrosplenic artery (*72*), runs ventrad along the cranial border of the spleen, which it supplies by a branch (*73*) immediately entering that organ. After a short distance the main trunk of the artery (*72*) divides into several branches, which supply the cæcal portion of the stomach and the distal loop of the intestine. The remaining three branches (*74*, *75*, *76*) are mesenteric arteries; two of them (*74*, *75*) supply the proximal portion of the intestine; the remaining one (*76*), which is the largest, runs caudad in the mesentary, and supplies the distal portion of the intestine and rectum.

Numerous variations occur in connection with the branching of the mesenteric vessels; for example, branches *74* and *75* often send twigs to the distal, as well as to the greater part of the proximal loop of the intestine.

*The subclavian arteries* (fig. 16, pl. I). The subclavian arteries (*77*) arise in common from the ventral surface of the dorsal aorta just caudal to the origin of the cœliacomesenteric artery. They run laterad, caudad, and somewhat ventrad to the base of the pectoral fin, where they terminate in two branches, the brachial artery and the ramus epigastricus descendens of Müller (1839). They give off a number of branches:

(a) About 1 cm. from the dorsal aorta, a branch (*78*), which runs dorsad and craniad, giving off a small branch to the cranial portion of the kidney, several branches to the muscles on the dorsal and caudal surface of the skull in the region of the supraoccipital bone, and finally, branches which terminate in the skin and cephalic crest. (b) A branch (*79*) which supplies the thymus gland[a] and adjacent muscles. (c) In addition to several small muscular branches, the coracoid artery (*80*) of Parker & Davis (1899) a short distance from the base of the pectoral fin, this vessel extending ventrad, close to the pericardium, and giving off numerous small muscular branches. At a point opposite the cranial end of the basipterygium, either the right or left coracoid artery joins the median hypobranchial. (d) The brachial artery (*81*) which supplies the pectoral fin. (e) The ramus epigastricus descendens (*82*), which runs caudad close to the skin and supplies the ventral abdominal muscles as far as the cloaca.

*The parietal arteries and their branches* (fig. 16, pl. I, fig. 15). The parietal arteries (*83*) arise from the dorsal aorta along its entire length, a pair opposite every other vertebra. They will be described in order.

The first pair are given off, as a rule, opposite the third vertebra, and, one on each side, curve laterad, dorsad, and craniad, then, after sending small branches to the cranial portion of the kidney, run dorsad to supply the dorsal parietal muscles.

The second pair are given off opposite the fourth vertebra, and run laterad through the kidney, to which both send one or more small arteries (*84*). At a point just lateral to the kidney each of the pair divides into a peritoneal, an intermuscular, and a dorsal branch. The peritoneal branch (*85*) runs ventrad close to the peritoneum and supplies the lateral abdominal muscles of that region. The intermuscular branch (*87*) extends laterad along the intermuscular bone to supply the adjacent muscles. The dorsal branch of the left side (*88*s) is small and runs dorsad to the membranes and muscles adjoining the fourth vertebra; the corresponding artery of the right side (*88*d) is quite large and runs dorsad, between the neural spines of the fourth and fifth vertebræ, to the lower end of the pterygiophores of the dorsal fin, where it divides into several muscular branches, two of which run dorsad, one on the right (*89*d) and one on the left (*89*s). Close to the skin each of these two branches divides into an anterior and a posterior vessel, the anterior running craniad and supplying the skin, while the posterior runs caudad to anastomose with the corresponding anterior branch of the next dorsal artery. The pairs of dorsal branches are throughout bilaterally asymmetrical, the larger branches being sometimes on one side and sometimes on the other. The smaller branch of each pair supplies the structures adjacent to the vertebral column. The larger branch, as already described, sends off on each side of the base of the dorsal fin an anterior and a posterior vessel which anastomose, respectively, with the posterior and anterior corresponding adjacent arteries, thus forming a more or less continuous vessel (*90*) on each side of the base of the dorsal fin. These vessels send numerous small branches (*91*) to the skin and dorsal fin.

---

[a] The thymus gland of the tile-fish is situated in the dorsal part of the gill chamber just cranial to the supra-clavicle. In fishes of about 50 cm. in length it is a triangular gland about 17 mm. long and 9 mm. wide; in the large individuals—those of about 85 cm.—it is very much reduced in size, traces of it, however, being always present.

The third pair of parietal arteries are given off opposite the sixth vertebra and have the same branches as the second, described above, with the addition of a small branch to the swim-bladder. This additional branch (*86*) arises from the peritoneal branch of each parietal artery and immediately enters the swim-bladder to supply, with its fellow of the opposite side, the anterior dorsal portion.

The fourth pair of parietal arteries arise opposite the eighth vertebra and have branches corresponding to those of the third. The vessel to the swim-bladder, however, is larger than the corresponding branch from the third pair, and supplies the median dorsal portion.

Between the origin of the fourth and fifth parietal arteries, though but slightly anterior to the latter, the dorsal aorta sends a large branch to the kidneys. This vessel, the posterior renal artery (*92*), leaving the ventral surface of the aorta, runs caudad and ventrad in the posterior division of the kidney, which it supplies, and sends a branch also to the bladder. A short distance beyond its origin it gives off two vessels, each of which almost immediately divides into a peritoneal branch (*85*) and a branch (*86*) which supplies the posterior dorsal surface of the swim-bladder.

The fifth pair of parietal arteries is given off opposite the tenth vertebra, just caudal to the posterior renal artery, as stated above. Each divides into a dorsal and an intermuscular branch. The peritoneal branch belonging to this segment arises from the posterior renal artery, as already stated.

The dorsal aorta at this point leaves the abdominal cavity and continues as the caudal aorta, inclosed by the hæmal arches of the caudal vertebræ. It gives off, opposite alternate vertebræ, three branches, two lateral, one on each side, and a median ventral branch. Each lateral branch divides almost immediately into an intermuscular (*87*) and a dorsal artery (*88*). The ventral branches (*93*) arise as median vessels from the ventral surface of the caudal aorta. They run ventrad in front of the hæmal spines of their respective vertebræ and divide into right (*94*d) and left (*94*s) branches which run ventrad, one on each side of the pterygiophores of the anal fin. At the base of the anal fin each one of these branches divides into an anterior and a posterior branch. These anastomose with corresponding vessels, thus forming a continuous artery on each side of the base of the anal fin (*95*) in the same manner as do the dorsal branches at the base of the dorsal fin, these continuous arteries (*95*) giving off small branches (*96*) to the skin and fin. The first ventral branch of the caudal aorta, which is given off opposite the eleventh vertebra, is somewhat larger than the more caudally situated ventral branches, and its anterior branch extends craniad to supply the muscles around the cloaca.

The caudal aorta terminates in two branches which run dorsad and ventrad, respectively (*97*), in a groove at the base of the caudal fin, supplying the latter by means of numerous small branches (*98*).

## THE VENOUS SYSTEM.

The veins (fig. 17, pl. I) will be described in the following order:

I. The hepatic portal system.
II. The veins opening into the sinus venosus.
III. The veins opening into the Cuvierian ducts.
IV. The caudal vein and venæ advehentes of the kidney.

### I. THE HEPATIC PORTAL SYSTEM.

The arrangement in the abdomen of the veins which form the hepatic portal vein is not at all constant. The order generally met with will be described.

At the base of the liver two main trunks (*41*, *50*) enter the large transverse hepatic portal vein (*40*) which distributes the blood through the liver. The larger of these two trunks (*41*) is formed by the union of the following vessels: (a) Branches from the rectum and distal portion of the intestine (*49*); (b) branches from the distal loop of the intestine (*47*) (principally from its left side); (c) a gastric branch (*46*) from the cæcal portion of the stomach; (d) a vein (*45*) from the spleen and distal loop of the intestine (principally right side) which joins the trunk opposite the right side of the stomach; (e) the small pancreatic vein (*44*), and a large vein (*43*) which leaves the ventral surface of the swim-bladder and returns the blood of the rete mirabile; and finally (f) a vein from the œsophagus (*42*) which joins the trunk just before it enters the liver. The second trunk, which helps to form the portal vein (*50*), returns blood to the liver from the greater part of the proximal loop of the intestine (*52*), and from the stomach by several gastric branches (*51*); it also, at times, receives branches from the distal loop of the intestine.

### II. VEINS OPENING INTO THE SINUS VENOSUS.

A. The hepatic veins (*2*), which are two in number, leave the right and left segments of the liver, one on each side of the median line, and empty immediately into the sinus venosus.

B. A large vein (*4*) from each side opens into the ventral surface of the sinus venosus near the Cuvierian duct. This vessel is formed by the union of the following three veins: (a) The brachial branch (*5*), which returns blood from the pectoral fin and from the anterior part of the lateral muscles of the abdomen (*6*); (b) a vessel (*7*), which returns blood from the ventral fin and ādjacent muscles, and (c) a vein (*8*), which returns blood from the thyroid gland and muscles ventral to the ventral aorta. Sometimes this latter vein (*8*) unites with its fellow of the opposite side by a small trunk (*9*) just below the ventral aorta. These three veins (*5*, *7*, and *8*) run close to the pericardium and, after uniting to form a single vessel on each side of the heart, open into the sinus venosus, as described above.

C. The Cuvierian ducts (*3*) open into the lateral extremities of the sinus venosus. They are two large vessels, about 2.5 cm. in length, situated on each side of the œsophagus just behind the fifth branchial arch.

### III. THE VEINS OPENING INTO THE CUVIERIAN DUCTS.

A. The inferior jugular vein (*10*), a large single vessel, its cranial end situated in the median line, returns blood from the lower jaw and floor of the mouth. Just caudal to the hypohyal, it receives two veins (*11*), one from each side, which return blood from the branchiostegal and ceratohyal regions, and, continuing caudad just dorsal to the ventral aorta, it curves to the right of the heart, close to the pericardium, and opens into the right Cuvierian duct near its junction with the sinus venosus.

B. The spermatic or ovarian veins (*13*), which return blood from the genital organs, run craniad in the abdominal cavity, emptying posteriorly into the Cuvierian ducts.

C. The jugular veins (*15*), two large vessels, one on each side, return blood from the head region. Behind the orbit each jugular vein is situated directly dorsal to the branchial arches and between the base of the cranium and the hyomandibular bone.

*Branches of the jugular vein.*—(a) The most cranial tributaries of the jugular vein are vessels (*26*) that return blood from the upper jaw and contiguous structures.

(b) About 1 cm. in front of the orbit the jugular receives a vein (*25*) from the olfactory organ and adjacent tissue.

(c) Ventral to the middle part of the orbit it receives the facial vein (*22*), which is formed by the union of a vessel (*24*) from the angle of the mouth and the m. adductor mandibulæ, and a branch (*23*) which returns blood from the operculum.

(d) Directly behind the orbit the right and left jugular veins are connected by the transversely situated interorbital vein (*19*). This vessel (*19*), which is about 2.5 cm. in length, arches between the two jugulars and in the median line receives the cerebral vein (*21*), which returns blood from the brain. It also receives the ophthalmic veins (*20*), which, one on each side, leave the eye at a point near the entrance of the optic nerve, and after passing between the rectus superior and externus usually receive branches from the eye muscles and open into the interorbital not far from the jugular. Sometimes, however, the vessels from the eye muscles open directly into the interorbital vein.

The jugular vein from this point continues caudad, partly surrounded by the cranial end of the kidney (K′), from which it receives branches, and opens into the dorsal end of the Cuvierian duct with the posterior cardinal vein of the same side. Three important vessels enter the cranial end of the kidney to empty into the jugular vein: The postorbital vein (*18*), which returns blood from the muscles of the head behind the orbit; the pharyngeal vein (*17*), which returns blood from the superior pharyngeal teeth, the muscles, and contiguous structures dorsal to the branchial arches; and a vein (*16*), which returns blood from the thymus gland, muscles, and membranes on the outer surface of the clavicle. These three veins (*16*, *17*, and *18*) enter the cranial end of the kidney, and, after giving off several venæ advehentes, usually unite to form a single vessel, which opens into the dorsal surface of the jugular vein.

D. The posterior cardinal veins (*14*) lie immediately ventral to the vertebral column, embedded in the substance of the kidney, and are asymmetrically developed. The left (*14*s) is small and its cranial portion, which is about 3 cm. long, functions as a vena revehentis renalis. The right cardinal vein (*14*d) is a vessel of considerable size; it receives at its caudal end a large vein (*37*) from the posterior division of the kidney, a connecting trunk (*36*d) from the caudal vein, and revehent branches from the kidney, as well as branches directly from the parietal veins; it then empties with the corresponding jugular vein into the right Cuvierian duct.

## IV. THE CAUDAL VEIN AND VENÆ ADVEHENTES RENALES.

The caudal vein (*35*) is situated in the hæmal canal just ventral to the caudal aorta. After receiving branches from the caudal fin (*39*) it collects blood from the tail region by means of ventral (*38*), dorsal (*29*), and intermuscular (*30*) veins. These are received opposite every other vertebra, and alternate with the arteries. After leaving the hæmal arches at the caudal extremity of the kidney the caudal vein divides into a right (*36*d) and a left (*36*s) branch. The right branch is short (*36*d) and opens directly into the right cardinal vein. The left branch (*36*s) runs forward in the substance of the kidney as an advehent vein, which, according to Parker (1884), is the remains of the posterior portion of the left cardinal vein.

Four veins empty into the enlarged posterior division of the kidney, two from each side of the body. The posterior pair (*34*) return blood from the ventral muscles just behind the cloaca, while the anterior pair (*33*) return blood from the posterior lateral muscles of the abdomen.

The parietal veins in the abdominal region consist of dorsal, intermuscular, and peritoneal branches. The dorsal (*29* to *29″*) and intermuscular branches (*30*) are received opposite every other vertebra, alternating with the arteries. The peritoneal branches (*31*) return blood from the lateral walls of the abdomen, and, in addition, each peritoneal vein receives a vessel (*32*) from the dorsal surface of the swim-bladder. The parietal veins in the abdominal region either enter and break up in the substance of the kidney as venæ advehentes (*31′*) or, after sending out advehent branches, connect directly with the right cardinal vein (*31*).

## REFERENCES TO FIGURES.

d. and s. denote *dextra* and *sinistra*, respectively.
A., auricle.
Af., anal fin.
Ar$^1$., first aortic root.
Ar$^2$., second aortic root.
B., branchial arch.
Ba., bulbus arteriosus.
Da., dorsal aorta.
Df., dorsal fin.
E., eye.
Hs., Hæmal spine.
K., kidney.
K′., cranial portion of kidney.
L., liver.
Ns., neural spine.
Œs., œsophagus.
P. D., pterygiophore of dorsal fin.
Ps., pseudobranch.
P. V., pterygiophore of anal fin.
V., ventricle.
Va., ventral aorta.

### ARTERIAL SYSTEM.

I′ to IV′. First to fourth afferent branchial arteries.
    *1.* Recurrent branch to ventralmost filaments.
I to IV. First to fourth efferent branchial arteries.
    I. First efferent branchial artery.
        *2.* Branch for dorsalmost filamentar vessels.
        *3.* Hyoidean artery.
            *4.* Muscular branch.
                *5.* Nutrient branch to first gill arch.
            *6.* Lingual artery.
            *7.* Branch to branchiostegal membrane and rays.
            *8.* Muscular branch to angle of mouth.
            *9.* Opercular branch.
            *10.* Afferent pseudobranchial artery.

  - *11.* Small muscular branch.
  - *12.* Direct afferent pseudobranchial artery.
    - *13.* Connection between direct afferent pseudobranchial and hyoidean arteries.
  - (*14.* Efferent pseudobranchial artery or ophthalmic artery.)
    - (*15.* Anastomosing trunk between the two ophthalmic arteries.)
  - *16.* Carotid artery.
    - *17.* Hyoöpercular artery.
      - Branch which divides into *19* and *20.*
        - *19.* To m. adductor mandibulæ.
        - *20.* Branch which joins the hyoidean artery.
      - *21.* Muscular branch to adductor and levator operculi.
      - *22.* Divides into *23* and *24.*
        - *23.* Supra-orbital branch.
        - *24.* Post-orbital branch.
    - *25.* Internal carotid artery.
      - *26.* Carotis interna impar.
        - Anterior cerebral artery.
        - Posterior cerebral artery.
    - *29.* External carotid artery.
      - *30.* Artery to rectus externus and superior.
      - *31.* Ocular artery.
      - *32.* Artery to rectus internus and inferior.
      - *33.* Small artery to membranes lining orbit.
      - *34.* Oblique artery.
      - *35.* Olfactory artery.
      - *36.* Branch in region of maxilla.
      - *37.* Superior dental artery.
- II. Second efferent branchial artery.
  - *38.* Fourth commissural artery.
    - *39.* Nutrient artery to second gill.
    - *40.* Nutrient artery to third gill.
    - *41.* Coronary artery.
  - *42.* Median hypobranchial artery.
    - *43.* Thyroid artery.
    - *44.* Muscular branch.
    - *45.* Muscular branch at ventral end of clavicle.
    - *46.* To ventral fins.
- III. Third efferent branchial artery.
  - *47.* Fifth commissural artery.
    - *48.* Nutrient artery to fourth gill.
    - *49.* Dorsal coronary artery.
    - *50.* Nutrient branch to rudimentary fifth branchial arch.
  - *51.* Sixth commissural artery.
  - *52.* Dorsal median hypobranchial artery.
- IV. Fourth efferent branchial artery.
  - *53.* Artery to superior pharyngeal teeth and membranes behind rudimentary fifth gill arch.
- *54.* Cœliacomesenteric artery.
  - *55.* First branch which sends out the following six branches:
    - *56.* Right œsophageal artery.
    - *57.* Right genital artery.
    - *58.* Hepatic branch.
    - *59.* Gastric and intestinal branches.
    - *60.* Branch which anastomoses with *66.*
    - *61.* Left hepatic artery.

  - *62.* Second branch of the cœliacomesenteric artery.
    - *63.* Left œsophageal artery.
    - *64.* Left genital artery.
    - *65.* Left gastric branch.
    - *66.* Branches of the latter which anastomose with *60* to form
      - *67.* Hepatic artery.
  - *68.* Artery to rete mirabile of swim-bladder.
    - *69.* Gastric branch.
    - *70.* Right hepatic artery.
  - *71.* Pancreatic artery.
  - *72.* Gastrosplenic artery.
    - *73.* Splenic artery.
  - *74.* Mesenteric branch.
  - *75.* Mesenteric branch.
  - *76.* Mesenteric branch.
- *77.* Subclavian artery.
  - *78.* Muscular branch.
  - *79.* Artery to thymus gland.
  - *80.* Coracoid artery.
  - *81.* Brachial artery.
  - *82.* Ramus epigastricus descendens.
- *83.* Parietal arteries.
  - *84.* Renal branches.
  - *85.* Peritoneal branches.
    - *86.* Branches to swim-bladder.
  - *87.* Intermuscular arteries.
  - *88.* Dorsal branch.
    - *89.* Branch on side of pterygiophores of dorsal fin.
      - *90.* Longitudinal vessel formed on each side of body at base of dorsal fin.
        - *91.* Branch to skin and dorsal fin.
- *92.* Posterior renal artery.
- *93.* Ventral branches.
  - *94 d.* and *s.* Right and left branches of *93*.
    - *95.* Longitudinal vessels.
      - *96.* Branch to anal fin and skin.
- *97.* Bifurcation of caudal aorta.
  - *98.* Branches to caudal fin.

VENOUS SYSTEM.

- *1.* Sinus venosus.
- *2.* Hepatic vein.
- *3.* Ductus Cuvieri.
- *4.* Vein which receives blood from *5*, *7*, and *8*.
- *5.* Brachial vein.
- *6.* Branch from lateral abdominal muscles.
- *7.* Vein from ventral fin.
- *8.* Vein from thyroid gland and muscles ventral to the ventral aorta.
- *9.* Anastomosing trunk.
- *10.* Inferior jugular vein.
- *11.* Vein from branchiostegal regions.
- *12.* Vein from teeth of lower jaw and floor of mouth.
- *13.* Genital vein.
- *14.* Posterior cardinal vein.
- *15s.* Left jugular vein.

*16.* Vein from thymus gland and contiguous muscles.
*17.* Pharyngeal vein.
*18.* Postorbital vein.
*19.* Interorbital vein.
*20.* Ophthalmic vein.
*21.* Cerebral vein.
*22.* Facial vein.
*23.* Branch from inside of operculum.
*24.* Branch from m. adductor mandibulæ and angle of mouth.
*25.* Vein from nose and adjacent region.
*26.* Vein returning blood from lips and teeth of upper jaw.
*27.* Venæ advehentes of kidney.
*28.* Venæ revehentes of kidney.
*29*, *29′*, *29″*. First, second, and third dorsal branches of parietal veins.
*30.* Intermuscular veins.
*31.* Peritoneal veins.
*32.* Veins from dorsal surface of swim-bladder.
*33.* Vein from lateral abdominal muscles.
*34.* Vein from muscles behind the cloaca.
*35.* Caudal vein.
*36d.* Connection between caudal vein and the right postcardinal.
*36s.* Left branch of caudal vein.
*37.* Venæ revehentes of the posterior enlarged portion of kidney.
*38.* Ventral parietal branches.
*39.* Branches from caudal fin.
*40.* Hepatic portal vein.
*41.* Branch which receives the following eight veins (*42* to *49*, incl.):
*42.* Oesophageal branch.
*43.* Vein from of rete mirabile of swim-bladder.
*44.* Pancreatic vein.
*45.* Vein from spleen and intestine.
*46.* Gastric branch.
*47.* Intestinal branch.
*48.* Branch of proximal loop of intestine.
*49.* Branch from distal portion of intestine.
*50.* Branch from stomach and proximal portion of intestine.
*51.* Gastric branch.
*52.* Vein from proximal loop of intestine.

## LITERATURE.

Allis, E. P.
1901. The Pseudobranchial Circulation in Amia calva. *Zoologische Jahrbücher*, Band XIV.

Allis, E. P.
1897. The Cranial Muscles and Cranial and First Spinal Nerves in Amia calva. *Journal of Morphology*, Vol. XII.

Ayres, H.
1889. The Morphology of the Carotids, based on a study of the Blood Vessels of Chlamydoselachus anguineus. *Bulletin of Harvard College*, Vol. XVII, No. 5.

Boas, J. E. V.
1880. Über Herz und Arterienbogen bei Ceratodus und Protopterus. *Morphologisches Jahrbuch*, Band 6.

Boas, J. E. V.
1880. Über den Conus arteriosus bei Butirinus und bei anderen Knochenfischen. *Morphologisches Jahrbuch*, Band 6.

Bumpus, H. C.
1899. The Reappearance of the Tilefish. *U. S. Fish Commission Bulletin for 1898.* Pages 321 to 333.

Cole and Johnston.
1901. Pleuronectes. *Liverpool Marine Biological Committee Memoirs*, Vol. VIII.

Dahlgren, Ulric.
1898. The Maxillary and Mandibular Breathing Valves of Teleost Fishes. *Zoological Bulletin*, Vol. II, No. 3.

Gegenbaur, C.
1898. Vergleichende Anatomie der Wirbelthiere. Band I. Leipzig.

Gemmill, J. F.
1898. The Pseudobranch and Intestinal canal of Teleosteans. *Report of the British Association for the Advancement of Science.*

Hyrtl, J.
1858. Das Arterielle Gefässsystem der Rochen. *Denkschriften der Kaiserlichen Akademie der Wissenschaften. Wien.* Band 15.

Hyrtl, J.
1872. Die Kopfarterien der Haifische. *Denkschriften der Kaiserlichen Akademie der Wissenschaften. Wien.* Band 32.

Martin, H.
1894. Recherches anatomiques et embryologiques sur les artères coronaires du cœur chez les vertébrés. Paris.

Maurer, F.
1884. Ein Beitrag zur Kenntnis der Pseudobranchien der Knochenfische. *Morphologisches Jahrbuch.* Band 9.

Maurer, F.
1888. Die Kiemen und ihre Gefässe bei anuren und urodelen Amphibien, und die Umbildungen der beiden ersten Arterienbogen bei Teleostiern. *Morphologisches Jahrbuch.* Band 14.

McKenzie, T.
1884. The Blood-vascular System, Ductless Glands, and Uro-genital System of Amiurus catus. *Proceedings of the Canadian Institute. Toronto.*

Müller.
1839. Vergleichende Anatomie der Myxinoiden. *Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin.*

Owen, Richard.
1866. The Anatomy of Vertebrates. Vol. I.

Parker, T. J.
1884. A course of instruction in zootomy.

Parker, T. J.
1886. On the Blood-vessels of Mustelus antarcticus. *Philosophical Transactions of the Royal Society of London*, Vol. 177.

Parker and Haswell.
1897. A Text-Book of Zoology. Vol. II.

Parker, G. H., and Davis, F. K.
1899. The Blood Vessels of the Heart in Carcharias, Raja, and Amia. *Proceedings of the Boston Society of Natural History.* Vol. 29, No. 8.

Parker, G. H.
1900. Note on the Blood Vessels of the Heart in the Sunfish (Orthagoriscus mola Linn.). *Anatomischer Anzeiger.* Band XVII, No. 16/17.

Reynolds, S. H.
1897. The Vertebrate Skeleton.

Ridewood, W. G.

1899. On the Relations of the Efferent Branchial Blood-vessels to the "Circulus cephalicus" in Teleostean Fishes. *Proceedings of the Zoological Society.*

Spencer, W. B.

1893. Contributions to our Knowledge of Ceratodus. Part I. The Blood Vessels. *Linnean Society of New South Wales. The Macleay Memorial Volume.*

Wright, R. R.

1885. On the Hyomandibular Clefts and Pseudobranchs of Lepidosteus and Amia. *Journal of Anatomy and Physiology.* Vol. XIX.

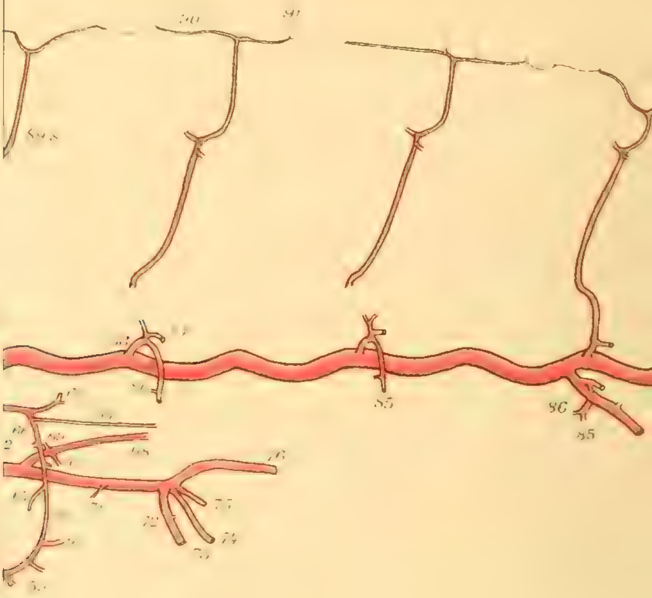

90
91
85
85
86
85
76
73
74
72

FIG. 16.

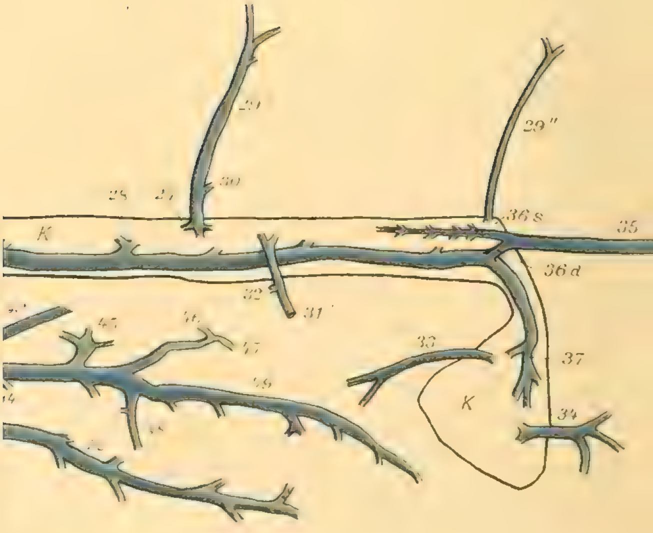

29
29"
30
28
27
K
36 s
35
36 d
32
31
45
46
47
33
37
49
K
34

FIG 17

LOPHOLATILUS C

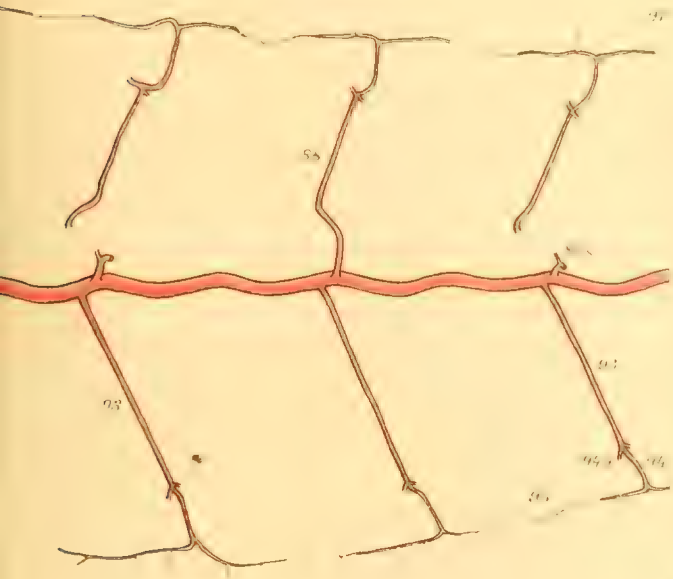
( NATU

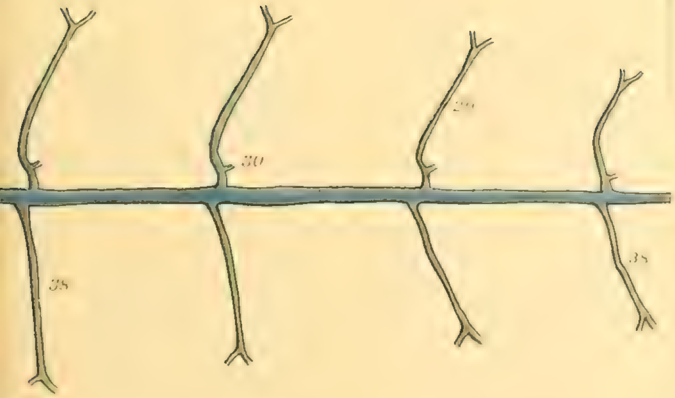
FIG. 16. ARTERIAL SYSTEM VIEWED FR

FIG. 17. VENOUS SYSTEM VIEWED FRO

FIG. 18. FIRST BRANCHIAL ARCH OF L

SHOWING ARRANGEMENT OF EF





MÆLEONTICEPS.
SIZE.)
LEFT SIDE.
LEFT SIDE
SIDE, VIEWED FROM FRONT,
ENT AND AFFERENT BRANCHIAL VESSELS.

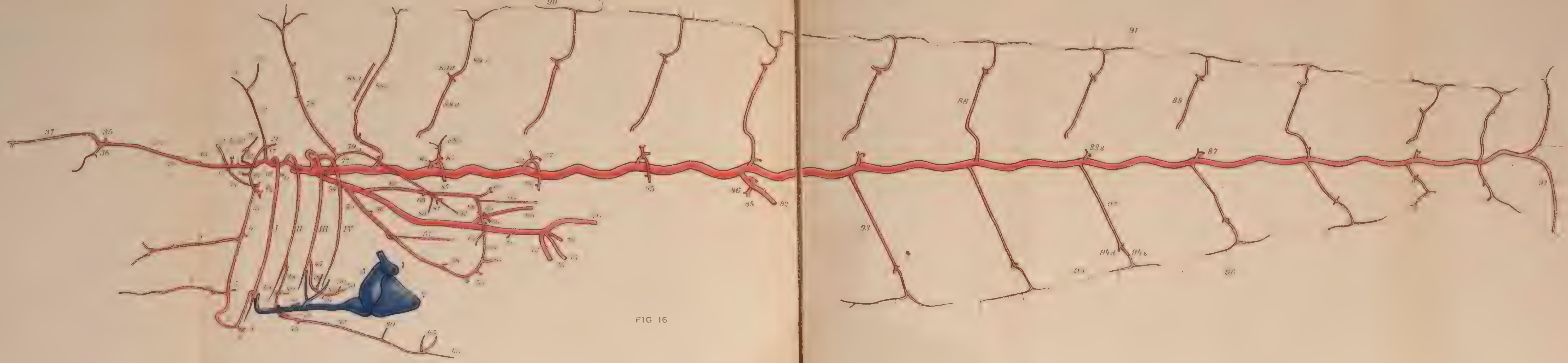

37
36
90
91
88
89s
87
85
86
92
93
94a
94b
96
98
97
I
II
III
IV
80

FIG 16

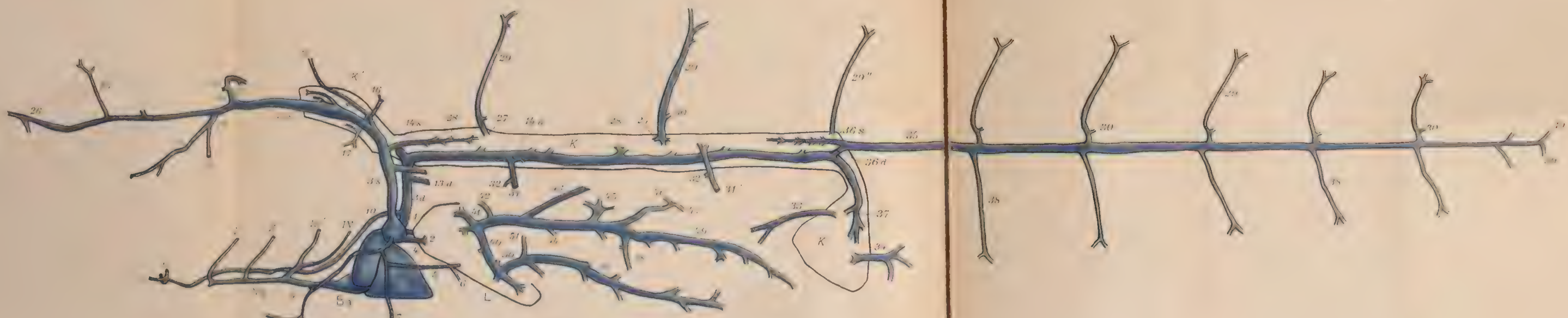

26
29
29"
14s
27
28
K
36s
36a
35
30
38
37
33
K
IV
5a
7
L

FIG 17

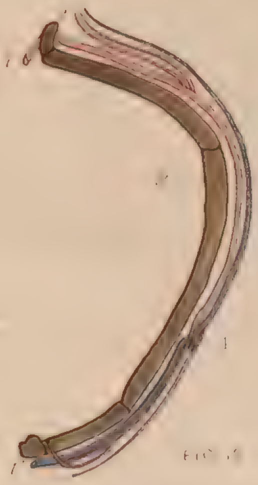


FIG 18

JULIUS BIEN & CO. N.Y.

LOPHOLATILUS CHAMÆLEONTICEPS
(NATURAL SIZE)

FIG. 16. ARTERIAL SYSTEM VIEWED FROM LEFT SIDE
FIG. 17. VENOUS SYSTEM VIEWED FROM LEFT SIDE
FIG. 18. FIRST BRANCHIAL ARCH OF LEFT SIDE, VIEWED FROM FRONT,
SHOWING ARRANGEMENT OF EFFERENT AND AFFERENT BRANCHIAL VESSELS.

CONTRIBUTIONS FROM THE BIOLOGICAL LABORATORY OF THE BUREAU OF FISHERIES
AT WOODS HOLE, MASS.

# THE FISH PARASITES OF THE GENUS ARGULUS FOUND IN THE WOODS HOLE REGION.

---

By CHARLES B. WILSON, A. M.,
*Department of Biology, State Normal School, Westfield, Mass.*

CONTRIBUTIONS FROM THE BIOLOGICAL LABORATORY OF THE BUREAU OF FISHERIES AT WOODS HOLE, MASS.

# THE FISH PARASITES OF THE GENUS ARGULUS FOUND IN THE WOODS HOLE REGION.

By CHARLES B. WILSON,
*Department of Biology, State Normal School, Westfield, Mass.*

The summer of 1871 witnessed the first effort on the part of the United States Fish Commission to obtain a knowledge of the invertebrate fauna of Vineyard Sound and adjacent waters, and thus of the parasites that infest the fish of that region. The results were embodied in an admirable monograph by Verrill and Smith, which has become the foundation of all subsequent work. In it were descriptions of three species of *Argulus*, all of which were new to science, but as they were captured while swimming freely at or near the surface, not even one of their hosts could be determined. Two other species were mentioned as likely to occur in the vicinity, but one of them, *alosæ*, had never been seen since 1847, when it was found by Harris in Boston Harbor and very poorly described by Gould in his Invertebrata of Massachusetts, while the other species, *catostomi*, had been found only upon the suckers in Mill River, near New Haven, Conn.

Since this first effort in 1871, the work has been carried forward steadily by members of the Fish Commission, and large collections have been made, showing the hosts for the various specimens taken. Especially should be mentioned the efforts of Mr. Vinal N. Edwards, whose extensive study of the fishes themselves has brought him frequently in contact with the parasites which infest them. Fully three-fourths of the entire collection of *Arguli* bear his signature, so that the determination of hosts and breeding seasons is almost wholly a result of his labors.

The material thus accumulated eventually found its way into the United States National Museum, and about a year and a half ago the entire museum collection was placed in the author's hands for purposes of study, at which time and since every facility within the command of the Fish Commission has been generously placed at his disposal. This has made it possible to determine with accuracy much that was previously in question with regard to the sexes of the *Arguli*, their breeding seasons, the place and manner of depositing the eggs, the period of incubation, the main features of development, and many of the habits that result from parasitism. These facts are embodied in a paper already published in the Proceedings of the United States National Museum (Vol. XXV), but as that paper includes all the known species of the *Argulidæ*, both American and foreign, fresh water and marine, it has been thought advisable to select the forms that are known or are likely to occur in the vicinity of Woods Hole, and give with them a list of the hosts upon which they are found, their breeding seasons, and such additional facts as may be of general value. They can thus be presented in a more compact form and one easier of reference for the working naturalist. There has also been included a description of the eggs and emerging larvæ, so far as known, for identification when found in the tow or (in the case of the eggs) upon the surfaces where they have been deposited.

There is good reason for supposing that all the species have three breeding seasons a year, but however that may be, the dates here given are those actually known from eggs deposited in aquaria or from females obtained full of ripe eggs. Most species occur upon the external surface of the fish's body and may usually be found near the fins or the operculum, but a few live within the gill cavity and are seldom found anywhere else. These localities have been indicated under the separate species.

This family often becomes important economically as a factor in the propagation and life history of our common food-fishes, especially fresh-water forms. Ordinarily the *Argulidæ* roam about so freely as to occasion little discomfort to their hosts. They change frequently from one species of fish to another, and must of necessity desert their hosts at the breeding seasons, since their eggs are deposited upon some convenient surface at or near the bottom, and are not carried about with them. Any fish, therefore, no matter how badly it may be infested, has a chance three times a year to get comparatively well rid of its argulid parasites. Furthermore, under ordinary conditions only a few specimens will be found upon a single fish, and these probably do not occasion any greater discomfort than the fleas upon a cat or dog, and they certainly do not menace the life of the fish in the least. We must not forget, also, that these parasites, like every other creature, have active enemies, and at certain critical periods in their development they also find serious obstacles to overcome. Thus the great majority of them are destroyed and they are kept within due bounds.

Let any of these conditions change, however, and the whole situation is reversed. If a fish for any reason becomes inert or debilitated the influence of the parasites is increased, and they may effectually prevent recovery and thus become at least the indirect cause of death. While the great majority of the *Arguli* prefer a sound, healthy fish, there are some species that seem to congregate upon diseased individuals. This is especially true of *Argulus megalops*, and almost every specimen of a summer or winter flounder that is diseased when captured will yield a harvest of this species. Yet even here we need to remember that the diseased condition is the cause and not the effect of the presence of the parasites.

Again, surrounding conditions may become unfavorable to the fish, but not particularly so to the parasite, thus weakening the resistance of the host. A change of this sort always takes places when migrating fish leave the salt water and ascend a river or stream for the purpose of spawning. Of course stationary parasites are taken along with their host as a matter of necessity, but it has also been satisfactorily proved that many species of *Argulus* can live in fresh as well as salt water and probably accompany their host as a matter of choice. As the fish gradually succumb to the rigors of migration the pernicious effect of the parasites is increased twofold. In the first place all the fish are weakened by the tremendous effort required and the accompanying abstinence from food, and therefore would feel the irritation more; and then as fast as any of the fish die these free-swimming *Arguli* can congregate upon the remainder and thereby increase their mischievous influence. Actual observations of the number of parasites present and their influence upon migrating fish are exceedingly meager and we have to be satisfied with a few crumbs of information, but it is more than evident that here is a field of inquiry which promises large returns for the future.

Another change that is always more unfavorable to the fish than to the parasite is the increase of temperature in our fresh-water ponds during the summer season. If the pond happens to be shallow there may be a sufficient rise to produce fatal results, along with the accompanying increase of *Arguli*. Several such instances are upon record. Mr. F. L. Washburn (American Naturalist, XX, p. 896) records the death of thousands of fish during the summer season for several years at Lake Mille Lac in Minnesota. This lake is quite shallow, and the water becomes correspondingly warm during July and August, at which time the fish die in such numbers that the beach is strewn for miles with their dead bodies. Washburn says:

> The evident cause of death is the presence of an external parasite, one of the Siphonostomata, which we found swarming on head, operculum, and belly. These parasites are translucent, disgusting looking creatures about the size and shape of a wood-tick, though many are larger, the abdomen furnished with an umbrella-like disk, which apparently assists them in clinging to their slippery hosts.

This is far from being a scientific description, but there is little doubt that a species of *Argulus* is referred to, especially when the kinds of fishes mentioned and the attendant circumstances are considered. The parasites had gathered upon the back of the fish, choosing most frequently a spot near the head, but often there were large patches upon the sides and belly. Washburn enumerates the following species among the dead: The wall-eyed pike (*Stizostedion vitreum*) was by far the most abundant; after this came yellow perch (*Perca flavescens*), rock bass (*Ambloplites rupestris*), black bass (*Micropterus*), bull-head (*Ameiurus*), crappy (*Pomoxis annularis*), calico bass (*Pomoxis sparoides*), whitefish (*Argyrosomus artedi*), ling (*Lota maculosa*), dogfish (*Amia calva*), pike (*Esox lucius*), and large suckers.

In the succeeding volume of the Naturalist (XXI, p. 188), Prof. R. Ramsay Wright mentions a corresponding mortality of an undetermined species of *Coregonus* in Lake of the Woods as reported to him by Mr. A. C. Lawson, of the geological survey of Canada. The death in this case was due almost entirely to a species of *Argulus* of which fortunately specimens were secured, and the author has had the pleasure of examining these recently. They prove to be *Argulus stizostethii* Kellicott, and thus add a new host for that species, besides confirming Kellicott's statement in regard to the original host, the blue pike (*Stizostedion vitreum*). This *Argulus* was first obtained from pike taken in the Niagara River at Buffalo, and Kellicott states that he has verified the reports of local fishermen to the effect that when the water is warm during midsummer this pike "gets too lazy to take food; that it then gets poor and, through its inertness, becomes infested with lice." They are usually found upon the top of the fish's head, often "huddled together in heaps, so the knife may remove a number at once."

It seems almost certain that some, at least, of the parasites found by Washburn must have been *A. stizostethii*, though there may have been other species also. Washburn recognizes the fact that the warm water played an important part in killing the fish, and he states that "in smaller lakes in the vicinity which are fed by springs, the fish are comparatively free from such enemies." In such instances, therefore, it is evident that the heat weakens the fish and renders it possible for the parasite to kill it if the latter is present in sufficient numbers.

After all, however, it is in restricted areas like artifical fish ponds, hatcheries, aquaria, etc., that these parasites become most troublesome. Here every condition deleterious to the fish is advantageous to the parasite. The artificial surroundings make more or less of a drain upon the fish's vitality, and since the number of fish is restricted, there is a resultant concentration of the evil effects produced by the parasites. They are always assured of a suitable host and are enabled to choose the strongest and healthiest fish, thereby lowering the general tone. If the breeding of *Arguli* is once started in such a place it will rapidly assume dangerous proportions unless checked at the very outset. This truth was clearly stated by the first observer of the *Arguli*. Leonard Baldneur, in a manuscript dated 1666, deposited in the public library at Strassburg, while speaking of what he calls the "pou des poissons" (*A. foliaceus*), says that it is seldom found except upon trout, which it frequently kills, especially if they are kept in ponds. The United States Fish Commission has had several such experiences and is constantly on guard against these *Arguli*. Sometimes it is necessary even to remove fish from the aquaria and clean them, as was recently the case at Ann Arbor, Mich. The fish were *Amia calva* and the parasites *Argulus americanus*.

It is chiefly to the natural enemies of the *Arguli* that we must look for a practical solution of this important problem in fish economy. The author has elsewhere recorded[a] some of these enemies discovered while investigating the cause of a serious mortality among the fish in a small artificial pond at Warren, Mass. Here the death was caused by a superabundance of *A. catostomi*. After much trouble the cause of the increase in these parasites was found to be the removal of all the small surface species, dace, roach, etc., which had been seined and sold for fish bait. These small fish feed upon the newly hatched *Argulus* larvæ, and as soon as they were restored to the pond the Arguli were reduced to their normal numbers and no further trouble has been experienced from them.

These facts have recently been confirmed by observations upon two species of *Fundulus* at Woods Hole. In September, 1902, many specimens of *A. fundulus* were obtained from *Fundulus majalis* and *F. heteroclitus*, both in the salt water of Woods Hole harbor and the almost fresh water near the head of Great Pond in Falmouth. On leaving Woods Hole, the writer attempted to take away some of the *Arguli* alive, for this purpose placing nine of the parasites upon two rugged specimens of *F. heteroclitus*, which were taken in a large fruit jar to Westfield, Mass. (125 miles), and placed in a salt-water aquarium. Everything progressed well for about three weeks, but not much food was given to the fish through fear of contaminating the limited supply of salt water. Consequently they became quite hungry, and one night deliberately *ate all the parasites*.

From these observations we are enabled to draw the following conclusions:

1. Under ordinary conditions it is not probable that the *Arguli* occasion their

---

[a] Proceedings of the United States National Museum, vol. xxv, p. 651.

host any serious inconvenience; their natural enemies keep them within due bounds and every fish has a chance to rid itself almost entirely of parasites when the latter are breeding.

2. If a fish becomes diseased the influence of the parasites is thereby increased, so that they hasten, and may partly cause, its death.

3. Fish while undergoing the rigorous efforts necessary to migration become greatly weakened and hence more susceptible to the influence of these pests.

4. The increased temperature of summer, especially in shallow fresh-water ponds, makes the fish so inert that they often become seriously infested, and are killed in large numbers.

5. The restrictions existing in aquaria, artificial hatcheries, etc., greatly assist these parasites, which speedily become a serious nuisance unless destroyed in some way.

6. Their most effective enemies are the smaller surface fish, dace, roach, etc., which eat the larvæ. Some minnows (*Fundulus*) will even eat the adults under the constraint of hunger.

7. The protection of these small fish and their introduction wherever possible is thus one of the most practicable preventives of any serious multiplication of the *Arguli*.

## DESCRIPTION OF SPECIES.

### KEY.

1. Carapace orbicular, wider than long, sucking disks very large.......2
   Carapace elliptical, considerably longer than wide, sucking disks relatively small.......4
2. Swimming legs of first and second pairs with recurved flagella.......*catostomi*, p. 123
   Swimming legs without flagella.......3
3. Basal plate of second maxillipeds with three stout teeth.......*funduli*, p. 125
   Basal plate prolonged posteriorly as an entire lobe without any teeth.......*latus*, p. 138
4. Swimming legs of first and second pairs with recurved flagella.......*laticauda*, p. 127
   Swimming legs without flagella.......5
5. Abdomen orbicular, wider than long, cut less than one-third, lobes well-rounded ..*megalops*, p. 129
   Abdomen elongate, longer than wide, cut to the center, lobes lanceolate-acuminate ....*alosæ*, p. 121

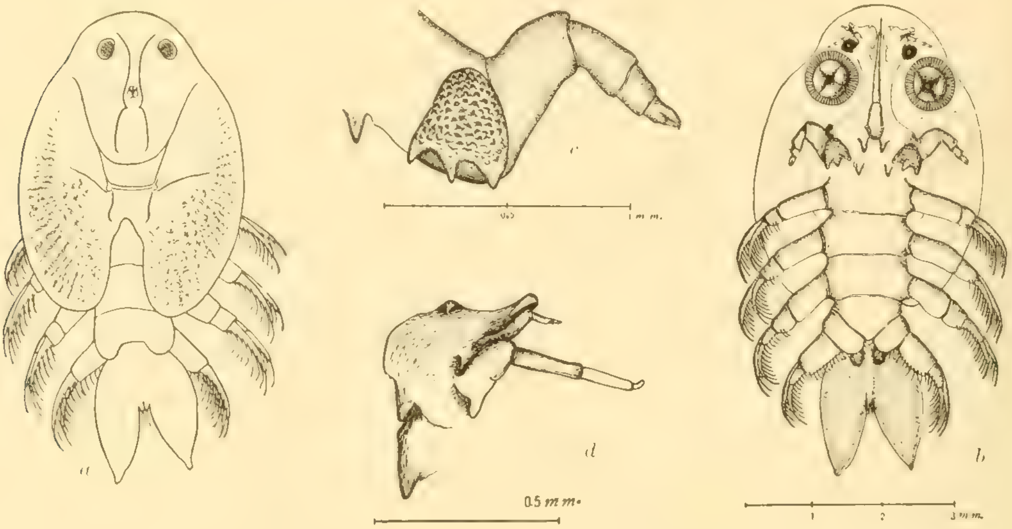
**Argulus alosæ** Gould. Male and female known.

Carapace relatively small, elliptical, much longer than wide, just reaching to the posterior thoracic segment; posterior sinus rather narrow and becoming contracted toward the base; eyes far forward, chitin rings in the lateral areas unequal, the smaller anterior to the larger, of nearly the same diameter, but much shorter; posterior segment of thorax projecting over the abdomen in a small rounded lobe on either side with a shallow sinus between; abdomen broad, elliptical, cut beyond the center; lobes divergent, lanceolate-acuminate; anal papillæ basal, no spines on the ventral surface of the carapace; antennæ rather small and poorly armed; posterior maxillipeds stout; basal plate triangular, considerably raised, and prominently roughened; posterior teeth short and blunt. Swimming legs reaching far beyond the carapace, without flagella; lobes on the basil joint of the posterior pair nearly rectangular and relatively very small. Male with no accessory sexual organs except the usual peg and semen receptacle; lobes of the basil joints of the posterior legs more pointed than in the female; abdomen much elongated; testes very large.

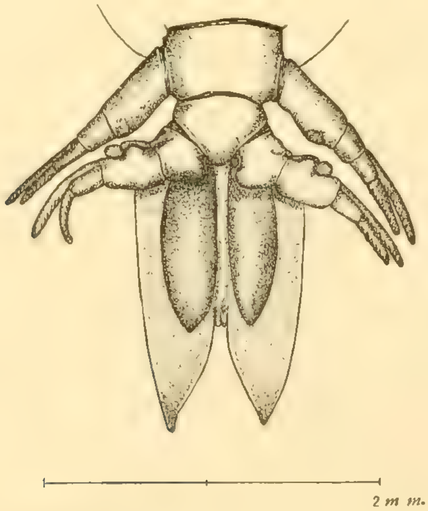
Color a uniform pale bluish-green with scattering pigment on the dorsal surface arranged in radiating dots and lines. Length of female, 7–10 mm.; length of carapace, 4–6 mm.; breadth of carapace, 3–5 mm.; length of abdomen, 2–3 mm.; breadth, 1.7–2.5 mm. Male about half this size. (Description from living specimens.)

Found upon the outer surface of the alewife (*Clupea pseudoharengus*) and the smelt (*Osmerus mordax*), usually in the vicinity of the fins; often numerous upon a single fish.

The eggs of this species are deposited in August (13th) and again toward the last of September and the first of October (September 24–October 5). Deposited eggs and larvæ unknown, but the eggs must be considerably larger than those of the other species and comparatively few in number, judging from the ripe females examined. A specimen from near Key West, Fla., taken in April, was full of apparently ripe eggs. Probably the species lays a little later than this around Woods Hole.



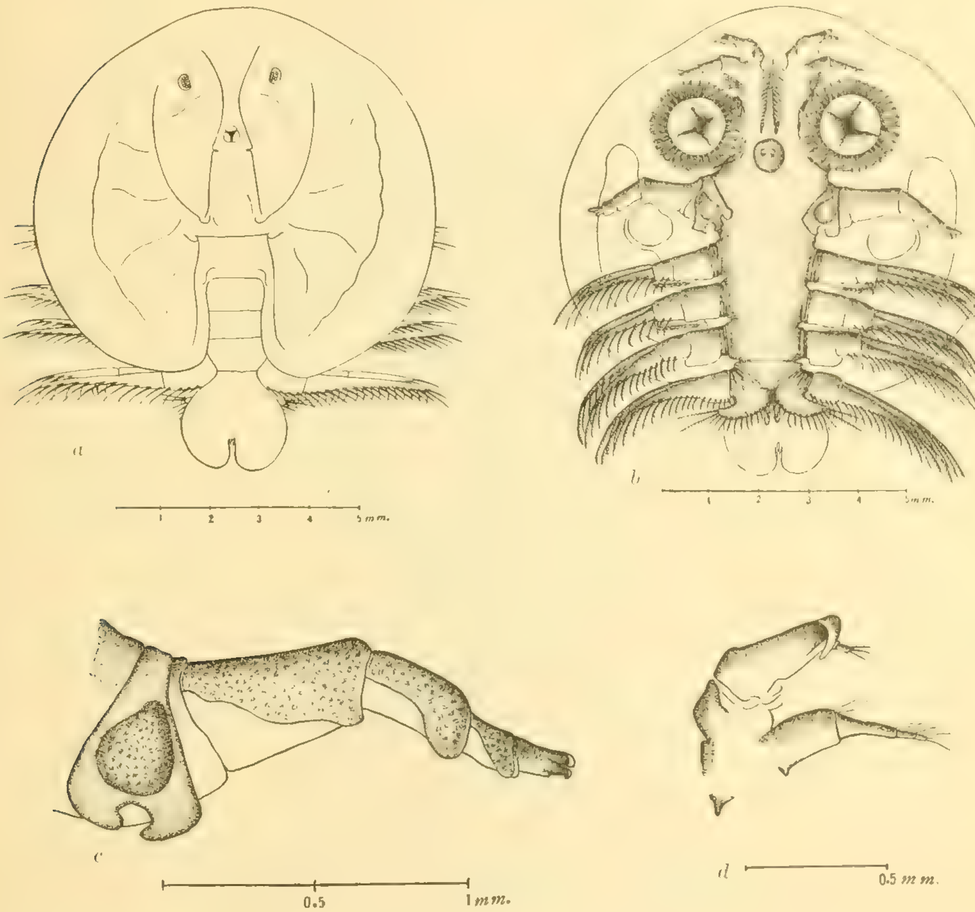
*Argulus alosæ* Gould. Female. *a*, Dorsal surface; *b*, ventral surface; *c*, posterior maxilliped; *d*, antennæ.



*Argulus alosæ* Gould. Male. Posterior legs and abdomen.

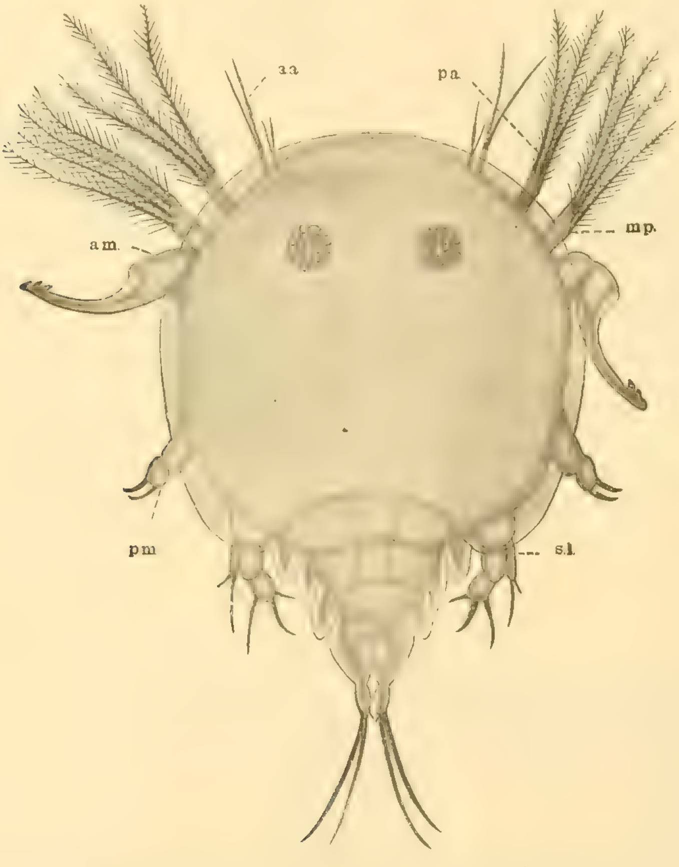
**Argulus catostomi** Dana & Herrick. Female only known.

Carapace large, orbicular, wider than long, almost covering the swimming legs; posterior sinus broad, with its sides approximately parallel; antero-lateral sinuses scarcely noticeable; chitin rings in the lateral areas very unequal in size, the larger one extending forward to the sucking disks, and having a deep indentation on its inner margin near the center, into which the smaller one projects. Abdomen comparatively very small, orbicular, wider than long, cut less than one-third its length; anal sinus narrow; papillæ basal. Antennæ comparatively small and weak; poorly armed; sucking disks large, placed well forward; second maxillipeds large and strong, every joint with a roughened area on its ventral surface; basal plate with a raised pear-shaped area near its center; lobes (not teeth) on its posterior edge broad and squarely truncated, usually three in number but often reduced by fusion to two. Swimming legs scarcely reaching the edge of the carapace; two anterior pairs with recurved flagella; lobes on the basal joints of the posterior pair medium size, boot-shaped. Color a uniform light sea-green, turning much darker in alcohol. Length, 12 mm.; length of carapace, 9.6 mm.; breadth of carapace, 11.2 mm.; length of abdomen, 2.3 mm.; breadth of abdomen, 2.4 mm. (Description from living specimens.)



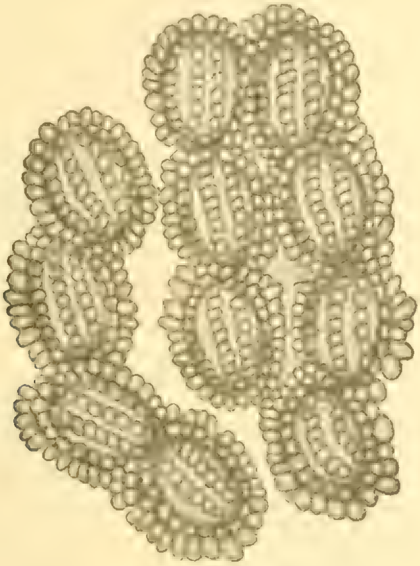
*Argulus catostomi* Dana & Herrick. Female. *a*, Dorsal surface; *b*, ventral surface; *c*, posterior maxilliped; *d*, antennæ.

Found upon the common sucker, *Catostomus*, and the chubsucker, *Erimyzon*, in both salt and brackish water; deposits its eggs the middle or the last of May (May 20–June 5). Eggs of medium size, arranged in short rows, gathered into small patches containing 6 or 8 to 12 eggs; rows not parallel; eggs placed end to end and covered with a jelly envelope, the surface of which is raised into long rows of club-shaped papillæ, which are often twisted spirally. Eggs hatch in 30–35 days; emerging larva light grayish in color, unpigmented, not very transparent, totally unlike the adult; carapace elliptical, longer than wide, but scarcely reaching to the center of the second (the first free) thoracic segment, leaving a very shallow posterior sinus; free thoracic segments rapidly diminishing in size. Abdomen narrower than last thoracic segment, elongate-triangular in shape, cut nearly to the center; anal sinus triangular; each lobe somewhat constricted at the base; papillæ terminal and ending in two very long setæ. Skin glands scattered about promiscuously, scarcely noticeable. Larva furnished with a temporary rowing apparatus, consisting of the greatly enlarged second antennæ and a pair of transitory mandibular palps, the former terminating in four long plumose setæ and a fifth much shorter, nonplumose one, like the thumb and fingers of a hand; the latter with 3

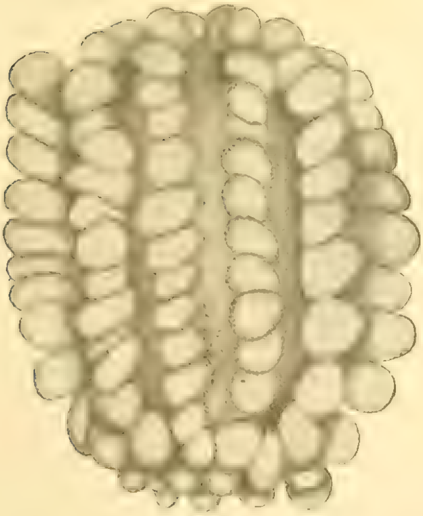


Newly hatched larva of *Argulus catostomi*, × 325. *a. a.*, Anterior antennæ; *p. a.*, posterior antennæ; *a. m.*, anterior maxillipeds; *p. m.*, posterior maxillipeds; *m. p.*, mandibular palp; *s. l.*, swimming leg.

plumose setæ; each anterior maxilliped terminating in a pair of stout, curved claws, the ventral one of which is barbed; only the first pair of swimming legs at all developed, the others mere rudimentary stumps.



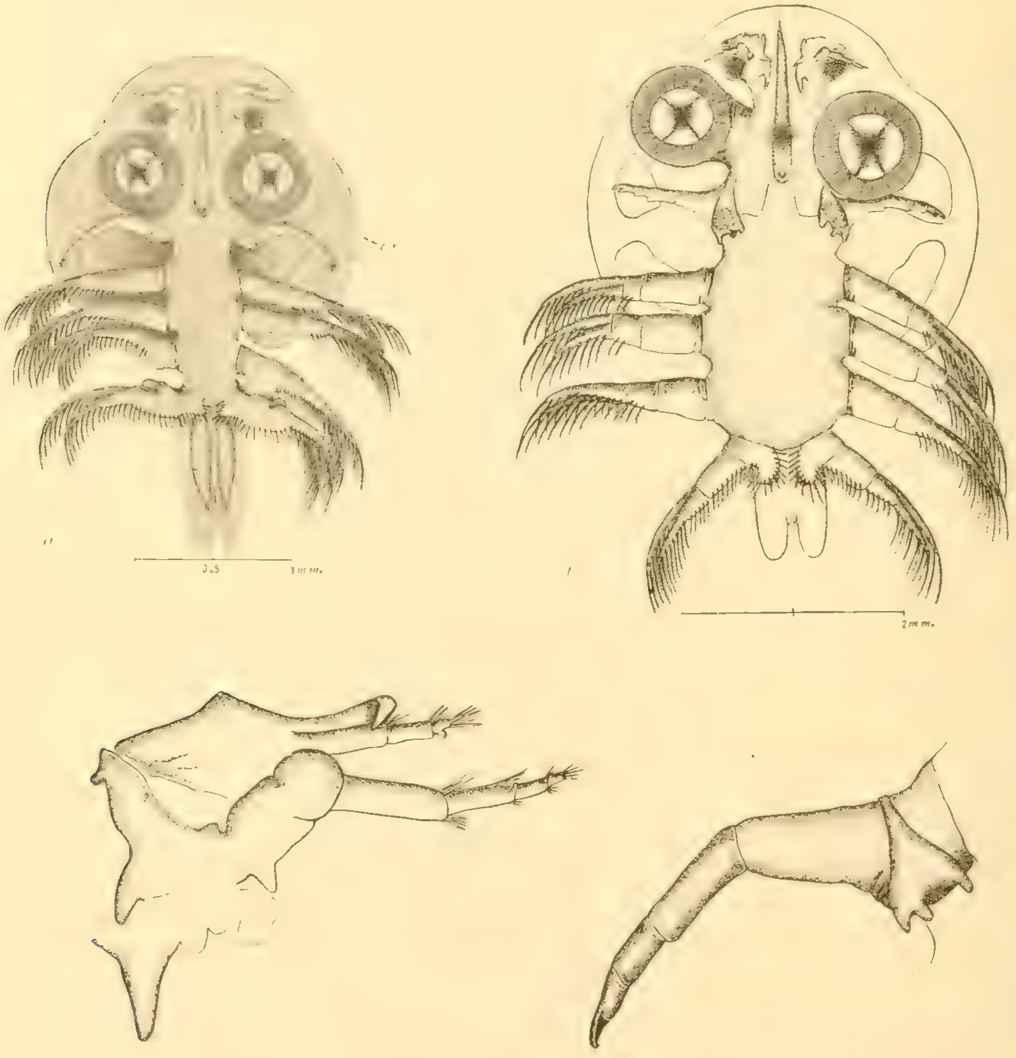
A single cluster of eggs of *Argulus catostomi.*
(Actual size, 0.45 × 0.3 mm.)



A single egg of *Argulus catostomi.* × 300.

**Argulus funduli** Kroyer. Male and female known.

Carapace orbicular, wider than long, scarcely covering the second pair of swimming legs; posterior sinus wide and shallow, widely cut at its base; eyes large and placed far forward, chitin rings in lateral areas nearly equal. On the ventral surface the anterior portion is covered with stout spines, while the whole thorax is papillated. Abdomen long elliptical, cut nearly to the center in the female, about one-fourth in the male. Antennæ large and well armed; sucking disks enormous, relatively the largest of any American species, occupying most of the breadth of the carapace; posterior maxillipeds long and slender; basal plate small, its teeth very short and blunt; anterior swimming legs reaching just beyond the edge of the carapace, posterior ones uncovered. Abdomen much elongated in the male, its lobes almost entirely filled by the large testes; a large conical appendage on the anterior of the swimming legs in addition to the regular accessory organs.



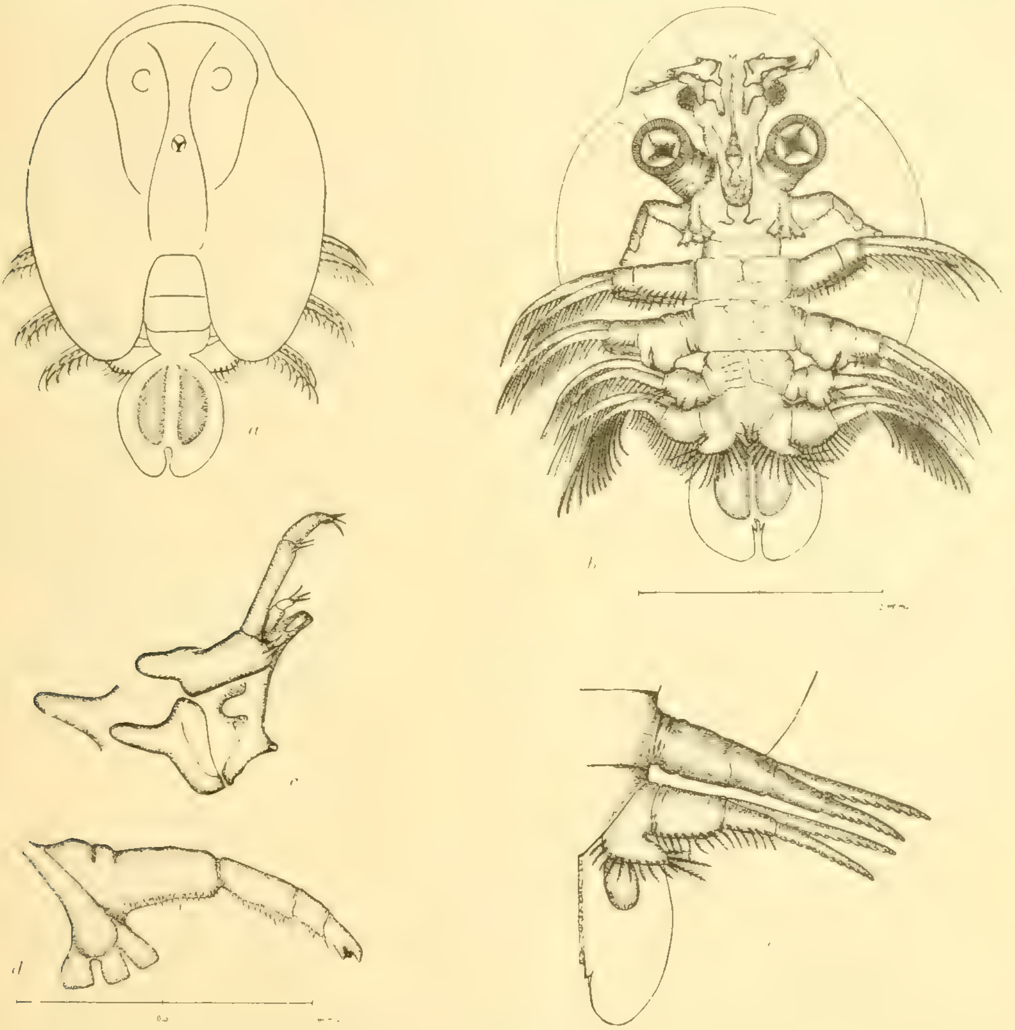
*Argulus funduli* Kroyer. *a*, Ventral surface of male; *b*, ventral surface of female; *c*, antennæ of male; *d*, posterior maxilliped of male.

Color yellowish-white, mottled with pale rust-color, the dorsal surface of the ovaries and testes heavily mottled with very dark brown pigment and thus contrasting strongly with the rest of the body. Length of the female, 5 mm.; length of carapace, 3.1 mm.; breadth of carapace, 3.5 mm.; length of abdomen, 1.1 mm.; breadth of abdomen, 0.6 mm.; male about three-fifths this size, but with an abdomen 1.3 mm. long. (Description from living specimens.)

Found upon the ventral surface of *Fundulus heteroclitus* and *Fundulus majalis* in both salt and brackish water; prefers the neighborhood of the fins; usually only one on a single fish; also likely to be taken in the tow during the breeding season. Deposits its eggs in July and October. Larvæ unknown.

**Argulus laticauda** Smith. Male and female known.

Carapace elliptical, longer than wide, just reaching the edge of the abdomen in the male; antero-lateral sinuses well-defined, leaving a large frontal lobe; posterior sinus wide and deep. Eyes large, chitin rings in the lateral areas concealed by the abundant black pigment. Abdomen orbicular, slightly longer than wide, cut less than one-third; anal papillæ basal. Antennæ large and stoutly armed; sucking discs small; posterior maxillipeds medium size, stout, with a fringe of spines along the entire posterior margin. Basal plate elongate and narrow, its posterior edge cut into three oblong, squarely truncated lobes instead of teeth. Two anterior pairs of swimming legs with recurved flagella and entirely covered by the carapace; lobes on the posterior pair long and pointed, boot-shaped. Males much larger than any females so far obtained, and with a conical projection on the anterior border



*Argulus laticauda* Smith. Male. *a*, Dorsal surface; *b*, ventral surface; *c*, first and second antennæ; *d*, posterior maxilliped; *e*, two posterior swimming legs of female.

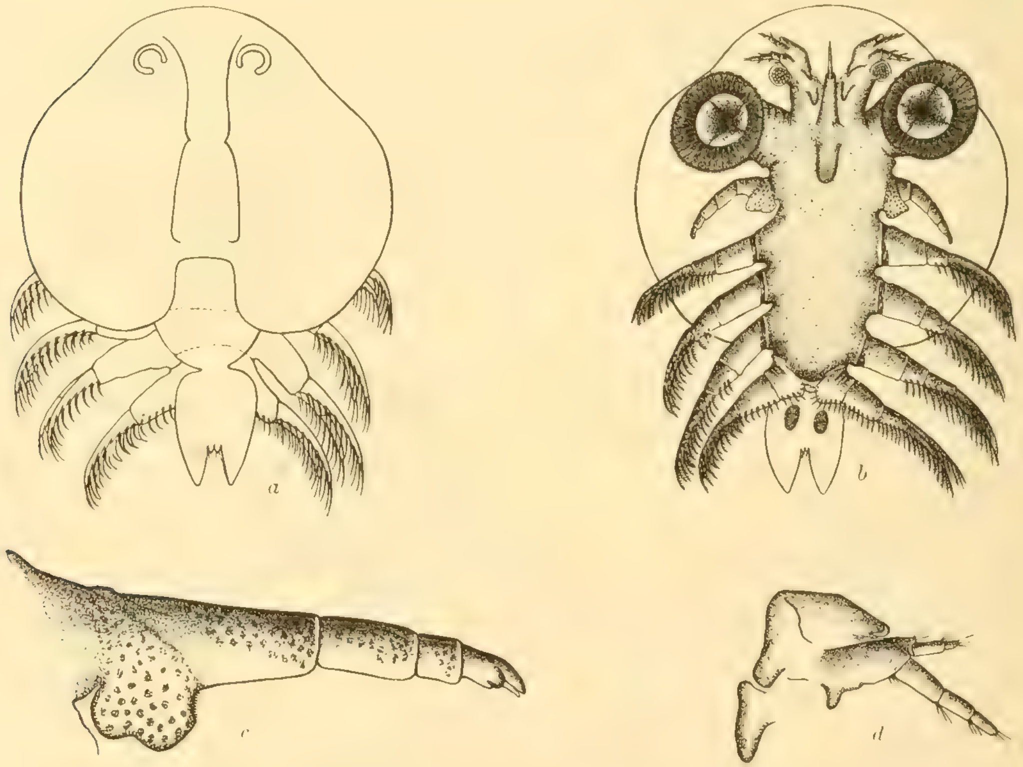
of the third legs and two large lobes on the posterior border of the second legs in addition to the regular accessory organs; testes medium size, hemi-ellipsoidal.

Color yellowish horn color, mottled with thick plack pigment arranged in more or less radiating spots and bands, often so dense as to make the creature almost entirely black. Pigment sometimes dark reddish brown, inclining to purple, especially in the smaller specimens. The only black or very dark *Argulus* and the only species in which the male is larger than the female. Length of male 5–7 mm.; length of carapace 3.5–4 mm.; breadth of carapace 3.2–3.5 mm.; length of abdomen 1.3 mm.; breadth of abdomen 1.1 mm. Female two-thirds this size. (Description from living specimens.)

Found most commonly upon the eel (*Anguilla chrisypa*) and various members of the Pleuronectidæ (*Pseudopleuronectes americanus, Paralichthys dentatus*). May be looked for occasionally upon the tomcod (*Microgadus tomcod*), upon skates, sculpins, and species of blenny. Deposits its eggs in August (14th) and the last of October (October 20–30). Larvæ unknown.

**Argulus latus** Smith. Female only known.

Carapace orbicular, wider than long, scarcely covering the second pair of legs; posterior sinus narrow and about one-fifth the length of the carapace; eyes large and very far forward. Abdomen narrow, elliptical, one-third as long as the carapace; anal sinus triangular, papillæ basal. Antennæ small but well-armed, widely separated; sucking discs very large and widely separated; posterior maxillipeds stout; basal plate uniformly papillated and prolonged backward as a whole without teeth or lobes. Swimming legs all reaching beyond the carapace, without flagella; lobes on the posterior legs small, rounded, triangular. Color yellowish-white, becoming brown in alcohol. Length 2.3 mm.; length of carapace 2.2 mm.; breadth of carapace 2.5 mm.; length of abdomen 0.7 mm.; breadth of abdomen 0.45 mm. (Description from alcoholic specimens.)

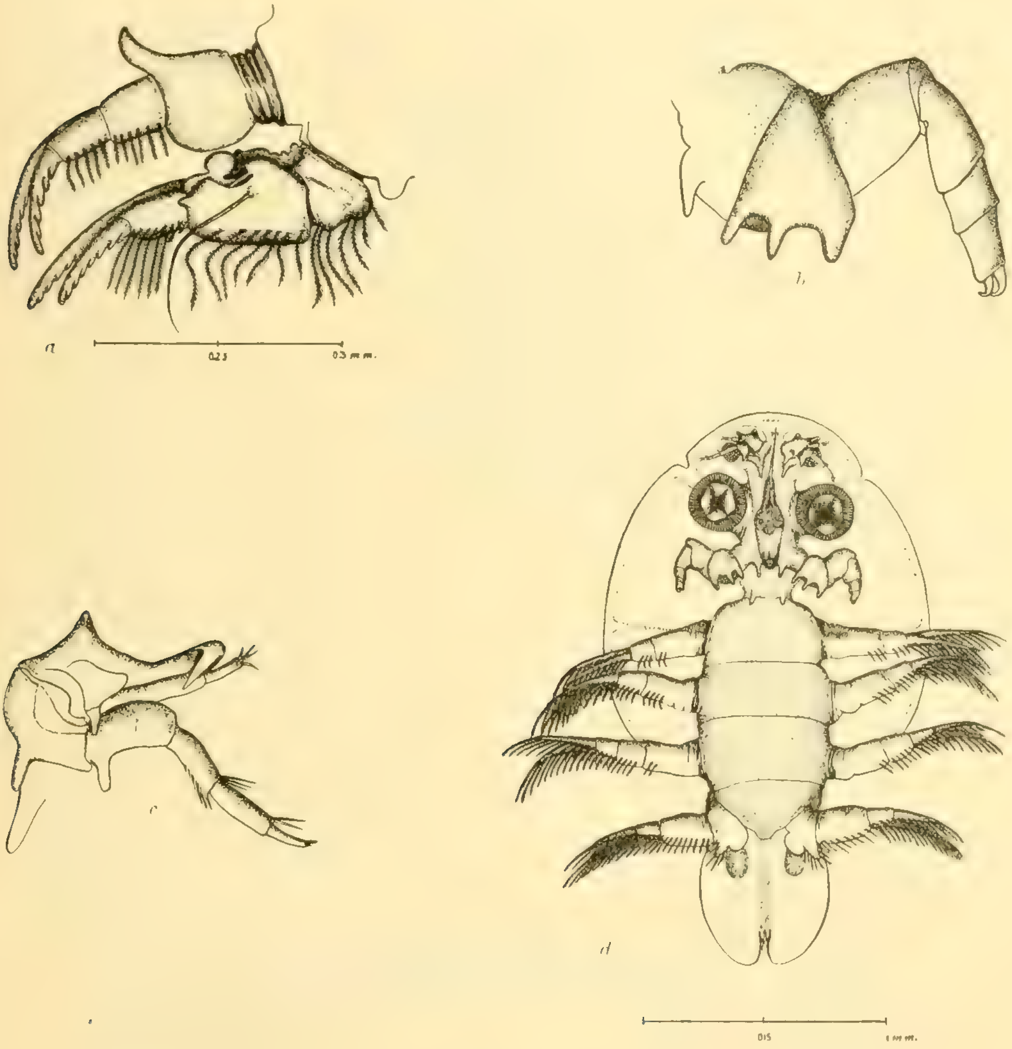


*Argulus latus* Smith. Female. *a*, Dorsal surface; *b*, ventral surface; *c*, posterior maxilliped; *d*, first and second antennæ.

Has been taken only at the surface, one specimen at Woods Hole and one at Casco Bay, both females. Egg deposition and larvæ unknown.

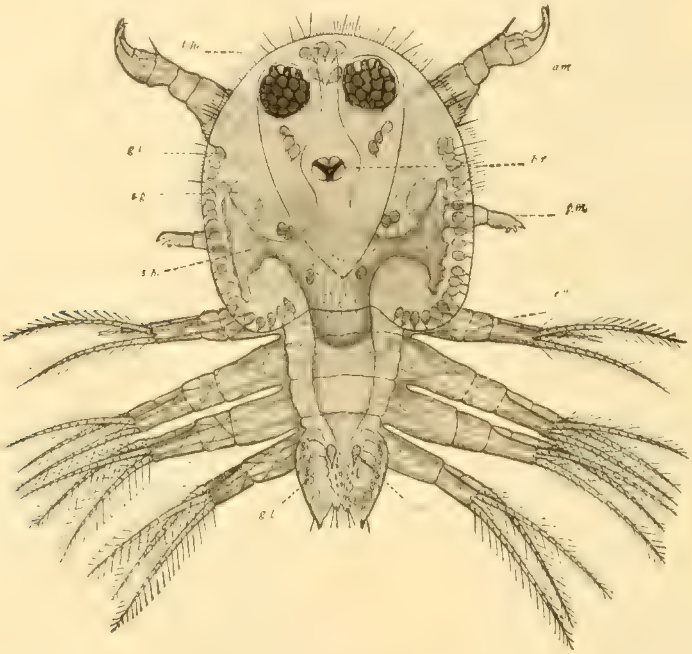
**Argulus megalops** Smith. Male and female known.

Carapace elliptical, longer than wide, scarcely covering the third pair of legs; posterior sinus triangular and shallow, lobes broadly rounded and free from the thorax. Eyes very large (one-tenth of the breadth of the carapace) and far forward; thorax partly uncovered, narrowing slightly posteriorly; abdomen broad elliptical, slightly longer than wide; anal sinus triangular (not more than one-fifth the entire length); papillæ basal. Antennæ medium, closely approximated and well-armed; sucking discs small. Posterior maxillipeds large, well-armed; basal plate broad triangular, teeth rather widely separated, stout and blunt. Swimming legs long, projecting far beyond the edge of the carapace, without flagella; lobes on posterior legs narrow and sharply pointed posteriorly. Male with a large thumb-shaped projection on the anterior border of the basal joint of the third legs, in addition to the regular accessory organs.



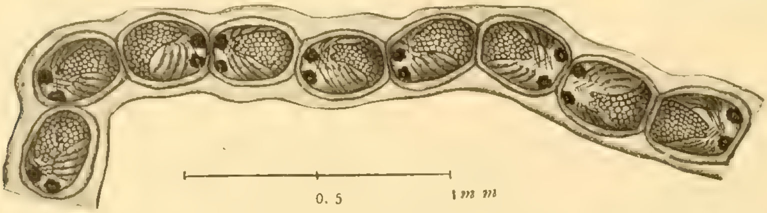
*Argulus megalops* Smith. *a*, Two posterior swimming legs of male; *b*, posterior maxilliped of male; *c*, antennæ of female *d*, ventral surface of female.

Color yellowish-white with four delicate longitudinal bands of pale yellowish pigment; the entire upper surface of the abdomen and the thorax in ripe females is red-brown, inclining to pink, thickly sprinkled with minute black dots; the lateral areas are also ornamented with an arborescent design in black pigment. Upon death the females frequently become a bright pink color. Length 6 mm.; length of carapace 3.8 mm.; breadth of carapace 3.5 mm.; length of abdomen 2 mm.; breadth of abdomen 1.4 mm. (Description from living specimens.)



Newly hatched female larva of *Argulus megalops*, × 235. *br.*, Brain; *en.*, endopod of first swimming foot; *gl.*, skin glands; *a. m.*, anterior maxilliped; *p. m.*, posterior maxilliped; *s. b.*, side branch of stomach; *s. g.*, shell gland; *s. r.*, semen receptacle; *t. h.*, tactile hairs.

Found most commonly upon the flounders (*Paralichthys dentatus, Pseudopleuronectes americanus*), upon or near the fins of which developmental stages may be secured in August and September. Has been found upon the common skate (*Raia erinacea*), the spotted sand flounder (*Lophopsetta maculata*), the sand dab (*Hippoglossoides platessoides*), and occasionally upon the sculpin (*Myoxocephalus octodecimspinosus*); upon the web-fingered sea-robin (*Prionotus carolinus*), the tomcod (*Microgadus tomcod*), the goose-fish (*Lophius piscatorius*), a species of minnow (*Fundulus*), and is frequently taken in tow. Deposits its eggs in August and September (August 31, September 1) and in October and November (October 14–November 2). Eggs placed end to end in single rows, 10 to 12 eggs in each row. Eggs yellowish-white, soon becoming dirty and brownish, 0.35 mm. long by 0.28 mm. wide; jelly covering perfectly smooth. Eggs require 60 days' incubation at a temperature of 72–75° F.



Eggs of *Argulus megalops* about ready to hatch. Actual size of one egg, 0.35 mm. long, 0.28 mm. wide.

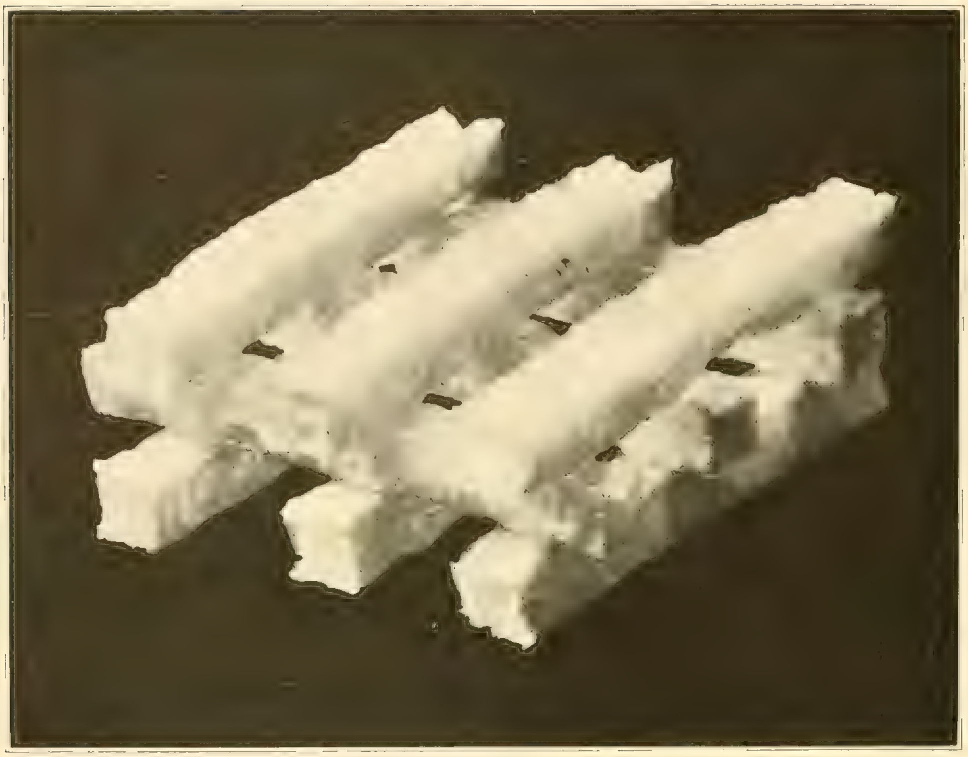
Emerging larva totally unlike that of *catostomi* and *foliaceus*, in a more advanced cyclops stage, with all the appendages except the first maxillipeds like those of the adult. Carapace elliptical, longer than wide, partly covering the base of the first pair of legs only; posterior sinus very wide and shallow; eyes one-fifth the width of the carapace, closely approximated, almost touching the anterior margin. Thorax narrowing gradually from in front backward; abdomen broad-elliptical, nearly as wide as long; anal sinus broadly triangular, papillæ basal; a very distinct row of small skin glands around the edge of the lateral areas of the carapace; five or six much larger ones along either margin of the abdomen. Antennæ thicker and stouter than in the adult, with the spines relatively larger; anterior maxillipeds four-jointed, terminating in two sickle-shaped hooks, the ventral one armed with barbs; there is also a stout spine on the anterior border of the terminal joint; posterior maxillipeds much smaller, five-jointed, each of the four basal joints armed on their ventral surface with a long curved spine and many shorter ones; basal plate with only two posterior teeth, but with a long spine on its outer margin. Swimming legs all perfectly developed; exopods one-jointed, with two long, plumose, rowing setæ; endopods of first pair three-jointed, first and second joints with sharp spines on their posterior border, third joint terminating in two similar spines, placed side by side; endopods of three posterior pairs of legs two-jointed with a single rowing seta.

The following is a list of the hosts upon which any species of *Argulus* has been found in the vicinity of Woods Hole:

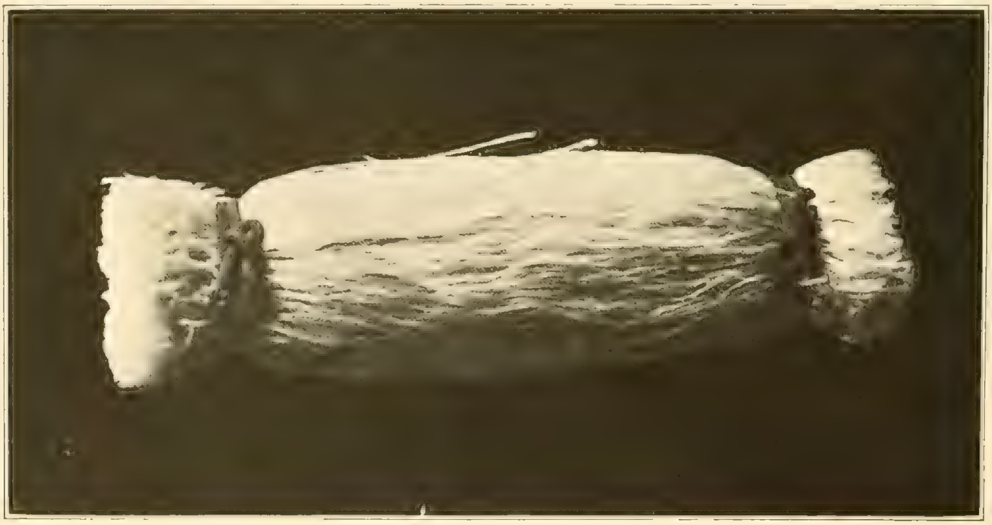
- Common skate, *Raja erinacea* Mitchill.
    - *A. laticauda*, *A. megalops*.
- Brook sucker, *Catostomus commersonii* (Lacépède).
    - *A. catostomi*.
- Chub sucker, *Erimyzon sucetta oblongus* (Mitchill).
    - *A. catostomi*
- Common eel, *Anguilla chrisypa* Rafinesque.
    - *A. laticauda*.
- Alewife, *Pomolobus pseudoharengus* (Wilson).
    - *A. alosæ*.
- Smelt, *Osmerus mordax* (Mitchill).
    - *A. alosae*.
- Killi-fish, *Fundulus majalis* (Walbaum).
    - *A. fundulus*, *A. megalops*.
- Killi-fish, *Fundulus heteroclitus* (Linnæus).
    - *A. fundulus*, *A. megalops*.
- Sculpin, *Myoxocephalus æneus* (Mitchill).
    - *A. laticauda*, *A. megalops*.
- Sea robin, *Prionotus carolinus* (Linnæus).
    - *A. megalops*.
- Blenny, sp.
    - *A. laticauda*.
- Tomcod, *Microgadus tomcod* (Walbaum).
    - *A. laticauda*, *A. megalops*.
- Sand-dab, *Hippoglossoides platessoides* (Fabricius).
    - *A. megalops*.
- Summer flounder, *Paralichthys dentatus* (Linnæus).
    - *A. laticauda*, *A. megalops*, *A. alosae*.
- Common flat-fish, *Pseudopleuronectes americanus* (Walbaum).
    - *A. laticauda*, *A. megalops*.
- Window pane, *Lophopsetta maculata* (Mitchill).
    - *A. megalops*.
- Goose-fish, *Lophius piscatorius* (Linnæus).
    - *A. megalops*.

# THE SEAWEED INDUSTRIES OF JAPAN.

By HUGH M. SMITH,
*Deputy U. S. Fish Commissioner.*



BAR OR "SQUARE" KANTEN.



A BUNDLE OF "SLENDER" KANTEN.

KANTEN, OR SEAWEED ISINGLASS.

# THE SEAWEED INDUSTRIES OF JAPAN.

By HUGH M. SMITH,
*Deputy U. S. Fish Commissioner.*

Seaweeds are among the most valuable of the aquatic resources of the Japanese Empire, and conduce largely to the prominent rank attained by the fisheries of that country. While marine plants are extensively utilized in France, Ireland, Scotland, and other European countries, in the East Indies, in China, and elsewhere, in no other country are such products relatively and actually so important or utilized in such a large variety of ways as in Japan.

The seaweed industries of Japan owe their importance to the great extent of the coast line (estimated at 18,000 miles); to the abundance and variety of useful algæ; and to the ingenuity of the people in putting the different kinds of plants to the most appropriate uses and in utilizing them to the fullest extent.

The value of the seaweeds prepared in Japan at the present time exceeds $2,000,000 annually, this sum excluding the value of very large quantities of marine plants which do not enter into commerce but are used locally in the families of the fishermen.

In view of the extent and long continuance of these industries, some diminution in the supply of economic algæ might reasonably be looked for, and this has in fact occurred; but while excessive gathering has influenced the abundance of some species, much more serious decrease has been brought about by conditions not connected with the seaweed industries. Investigations conducted by the imperial fisheries bureau have indicated that the disappearance of useful algæ on a number of sections of the coast has resulted from a temporary freshening of the littoral waters, probably owing to improper lumber operations near the headwaters of streams. The denuded areas have always been contiguous to the mouths of rivers or within the possible range of influence of streams during freshets. It is reported that in a few places certain algæ have been able partly to reestablish themselves, but the process is very slow, and complete replenishment will require many years, even if no lowering of water density ensues in the meantime. Some experimental planting in the denuded districts has been undertaken with favorable results, but on a very small scale. In other parts of Japan cultivation is extensively carried on, but as yet is directed to practically only one species, the laver (*Porphyra laciniata*).

It is noteworthy that the disappearance of seaweeds has injuriously affected another fishery—namely, that for abalones, which rank among the important water products of Japan. These mollusks feed among the algæ and are no longer found on large areas of bottom on which they formerly abounded.

The general name applied to algæ in Japan is nori, which is also often given to the prepared products. The term enters into numerous combinations, as will be seen in the following chapters. The seaweed preparations to which special attention is given are kombu, amanori, funori, kanten, and iodine. All of these can be made in the United States, and it is largely with a view to pointing out the possibilities for a successful business in some or all of these products that this report is submitted.

The information herewith presented embodies a brief account of the methods of taking and utilizing seaweeds in Japan, and is based on personal inquiries by the writer in 1903. Statistical and other useful data have been furnished by Dr. K. Kishinouye and Dr. K. Oku, of the imperial fisheries bureau, Tokyo. To Doctor Oku, especially, the writer is under great obligations for assistance and information, without which the preparation of this paper would have been impracticable. A number of manufacturers of seaweed products supplied samples, gave information, and accorded facilities for inspecting their establishments; among those to whom special acknowledgments are due are Messrs. Risuke Yamamoto, Hikobei Nakanisi, Hikobei Matsushita, Kingo Matsushita, and Manjiro Nakajima, all of Osaka.

The biological and commercial aspects of the Japanese seaweeds have been considered in various official reports, the most complete of which are published only in the Japanese language and are not available for foreign readers. The following publications have been consulted in the preparation of this paper, and some of the illustrations herein shown have been copied or adapted therefrom. Only the first three papers are in English.

JAPANESE BUREAU OF AGRICULTURE.

1893. Useful Algæ, in Descriptive Catalogue of Exhibits relating to the Fisheries of Japan at the World's Columbian Exposition. Tokyo, 40 pages.

1894. Utilization of Algæ, in The Fisheries of Japan. Compiled and arranged from the foregoing catalogue by Hugh M. Smith. Bulletin U. S. Fish Commission, 1893, pp. 419–438.

K. YENDO.

1902. Uses of Marine Algæ in Japan. Postelsia, The Year Book of the Minnesota Seaside Station, 1901, pp. 1–18. St. Paul, 1902.

1903. Investigations on Isoyake (decrease of seaweed). Journal of the Imperial Fisheries Bureau, Vol. XII, No. 1, 1903.

MIYABÉ, YAMAGAWA, AND OSHIMA.

1902. On the Laminariaceæ and Laminaria Industries of Hokkaido, being Part III of Report on Investigations of the Marine Resources of Hokkaido, pp. 212, numerous plates. Sapporo, 1902.

I. On the Laminariaceæ of Hokkaido. By Prof. Kingo Miyabé.
II. On the Laminaria Industries of Hokkaido. By Shin Yamagawa.
III. Chemical Analysis of Laminaria. By Prof. Kintaro Oshima.

T. NISHIMURA.

1903. Manufacture of Funori (seaweed glue) in the Prefectures of Tokyo, Osaka, and Miyé. Journal of the Imperial Fisheries Bureau, Vol. XII, No. 3, 1903.

K. OKU.

1904. Preparation of Kizami-kombu (green-dyed laminaria) in the Prefecture of Osaka. Journal of the Imperial Fisheries Bureau, Vol. XIII, No. 2, 1904.

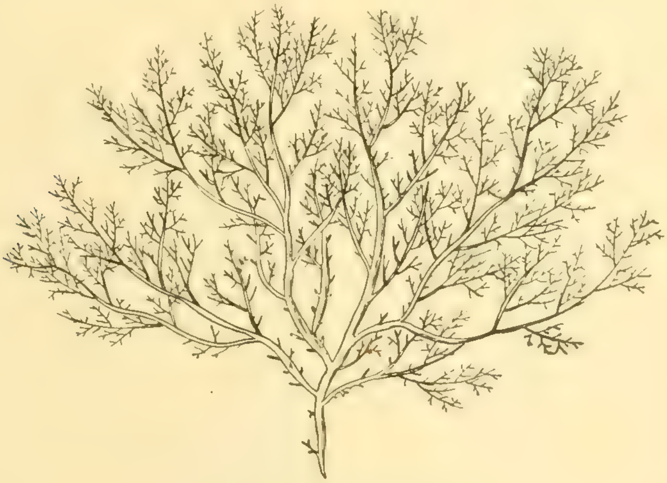
## KANTEN, OR SEAWEED ISINGLASS.

### NATURE AND IMPORTANCE OF KANTEN.

A very valuable and interesting product of seaweeds, comparable to isinglass and used for some of the same purposes, is known to the Japanese as *kanten*. This name is like so many of the fanciful terms with which the Japanese invest common objects; it means "cold weather," and has reference to the circumstance that this article is and can be made only during the colder months (December to February).

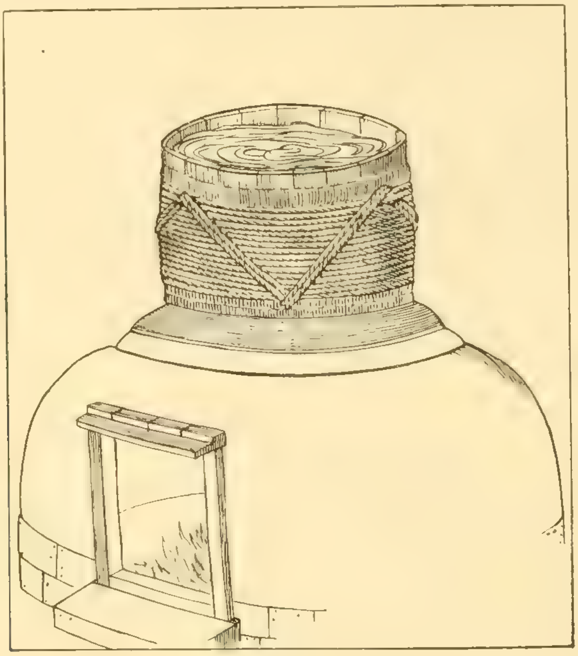
In 1903 there were in Japan 500 establishments for the manufacture of kanten, located in Osaka, Kyoto, Hyogo, Nagano, and elsewhere. The average capacity of the factories is 3,000 kin, or about 4,000 pounds. The leading manufacturer has his warehouses and store in Osaka, and his factory at Hyogo, where 70 to 80 persons are employed. Mountainous regions are the best for this industry, because of the dryness and purity of the air.

Kanten has been made since about 1760. In the early years it was simply a mass of jelly formed by the boiling of the seaweed, but at the present time the entire output is in the more convenient form of sticks and bars, a manner of preparation which was taken up quite accidentally; some soft jelly was thrown out of doors and congealed in the shape of slender sticks, suggesting the idea of preparing it in this form. Kanten is made from algæ of the genus *Gelidium*, the principal species being *G. corneum*. The Japanese name for the plant is *tengusa*, a contraction of *kantengusa*, meaning "weed for kanten." Several similar seaweeds are used as substitutes or adulterants, but are not so good as *Gelidium*. The algæ grow on rocks, and are taken by diving, the gathering season being May to October, though July and August are the best months. The principal supply comes from Hokkaido and the prefectures of Shizuoka, Miye, and Wakayama. The weed is dried on the shores, some bleaching taking place at the time of drying, and is then ready for sale to the manufacturers.

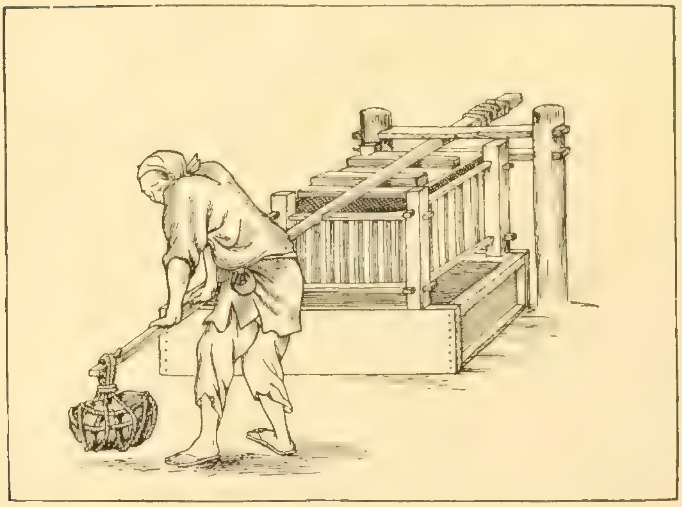


"Tengusa" (*Gelidium corneum*).

In 1903, the dried weed was selling in Osaka at 6 to 9 cents per pound; the substitute algæ brought 4 to 6 cents. The total crop of dried kanten algæ in 1900 was valued at $113,140; the fishermen's sales in 1901 were $125,282.



Furnace and tub for the boiling of *Gelidium*.



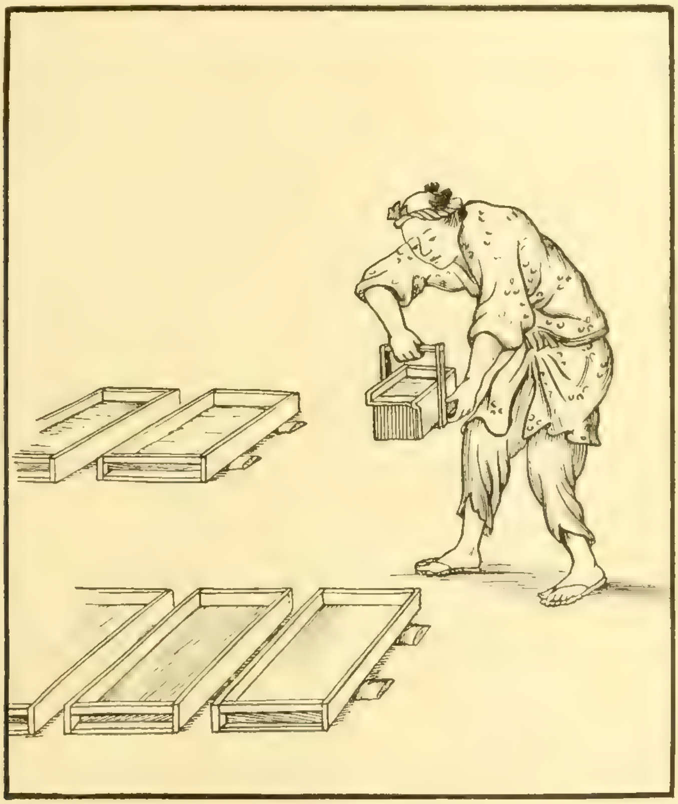
Press for straining crude sea-weed jelly.

THE PREPARATION OF KANTEN.

The process of making kanten is quite elaborate, although the appliances required are simple and inexpensive.

(1) The first step is the removal of all foreign matter from the masses of dried algæ. Calcareous and other hard particles are dislodged by beating and pounding, and other substances are picked out by hand. Further cleaning is effected by washing in running fresh water.

(2) The wet algæ are then spread in thin layers on flakes with bamboo or reed tops, through which the water drains. The principal object in thus spreading the algæ is to bleach them; this is done in warm weather, beginning in August, and is facilitated by dew. Under favorable conditions, twenty-four hours may be sufficient, but usually several days are required.



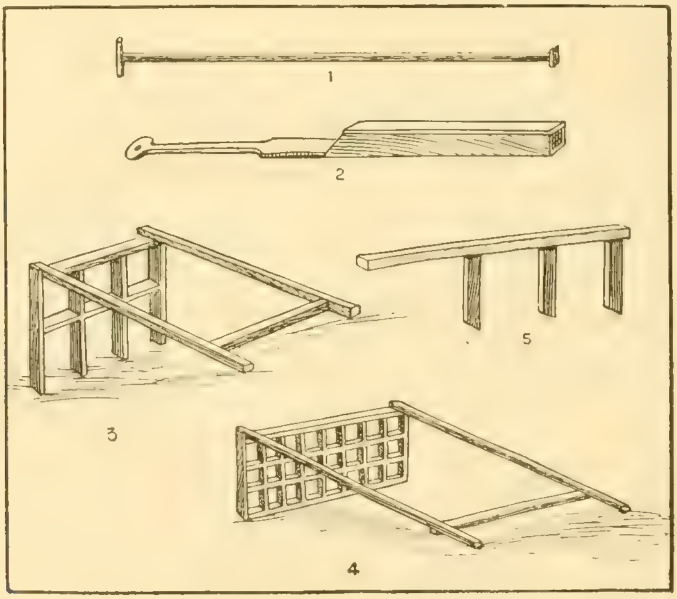
Pouring liquid kanten into cooling trays.

(3) As the drying goes on, the algæ become agglutinated and more or less fused, forming loose-meshed sheets. These sheets are loosely rolled and, as required, are boiled in fresh water in a large iron kettle or a wooden tub placed over a specially constructed oven or furnace. The boiling extracts the gelatin, and a thick, pulpy mass results. From the boiling kettle the jelly is strained or filtered through coarse cloths into a vat or tank, this preliminary straining being followed by a more thorough straining through linen bags of coarse mesh, which are placed in a crib and squeezed by means of a lever, the jelly falling into a large vat under the press.

(4) From the vat the jelly is dipped with a peculiar rectangular wooden vessel and poured into wooden trays to cool. These trays are about 2 feet long, 1 foot wide, and 3 inches deep, and are arranged in rows in the open air, resting on parallel poles so as to be clear of the ground.

(5) At a certain stage of the cooling and hardening process, the contents of the trays are cut into pieces of uniform size, in order to facilitate handling. The cutting is done by means of oblong iron frames, adapted to the shape of the trays, divided into squares of various sizes. One face of the frame has sharpened edges, and the cutting is done by inserting the frame along one side of the tray and drawing it horizontally through the jelly.

(6) The bars are then put one by one in a wooden box slightly larger than themselves and with a coarse wire grating over the lower end. A wooden piston with a broad end fits into this box, and is pushed against the bar of jelly, forcing it through the grating in the form of slender sticks. Another way in which kanten is prepared is in the form of blocks, 1¼ to 1½ inches square and 10 to 12 inches long, which are made with a cutting frame such as has been referred to. There is a shrinkage of one-third in bulk in the course of solidifying.



Articles used in cutting sea-weed jelly into sticks and bars.

(7) The sticks and bars of hardening jelly are arranged in regular rows on flakes occupying an exposed position on a mountain or hillside. The congealing requires one to three days, according to wind and temperature, and a further drying of three or four days is usually allowed. A northwest wind is considered as giving the best results.

(8) The thoroughly dried pieces are trimmed to uniform lengths and baled for shipment. The thin sticks, known as *huoso-kanten* (slender kanten), are 10 to 14 inches

long and about one-eighth of an inch thick, and are tied into bundles weighing about 6 to 10 ounces ; the bundles are packed in bales holding 100 kin (133 pounds), incased in several layers of matting. The blocks, which are called *kaku-kanten* (square kanten), are not adapted for close packing, and make a very bulky bale; about 50 blocks weigh 1 pound.

### THE USES OF KANTEN.

Kanten is pearly white, shiny, and semitransparent, having in block form a loose, flaky structure, and is tasteless and odorless. In cold water it swells but does not dissolve, but in boiling water it is readily soluble and on cooling forms a jelly.

In Japan kanten is used largely for food in the form of jellies (often colored), and as adjuvants of soups, sauces, etc. It is also used for purifying saké, the native wine made from rice. In foreign countries kanten is employed in a variety of ways, although chiefly in food preparations where a gelatin is required, such as jellies, candies, pastries, and many desserts, in all of which it is superior to animal isinglass. It is also used for the sizing of textiles, the stiffening of the warp of silks, the clarifying of wines, beers, coffee, and other drinks, the making of molds required by workers in plaster of Paris, and sometimes in the manufacture of paper. In China one of its uses is as a substitute for edible bird nests. The large consignments of square kanten to Holland are doubtless destined for the schnapps factories. A very important use in all civilized countries is as a culture medium in bacteriological work; the product is known in the scientific world under the name *agar-agar*, which is the Ceylonese equivalent of kanten. For this purpose a very pure grade of slender kanten is required.

The following chemical analyses of kanten have been made by Dr. O. Kellner, formerly a professor in the Agricultural College of Tokyo University, and by the Imperial Fisheries Bureau, respectively:

| Substances | I | II |
|---|---|---|
| | *Per cent* | *Per cent* |
| Water | 22.80 | 22.29 |
| Protein | 11.71 | 6.85 |
| Fiber | | 6.75 |
| Carbohydrates | 62.05 | 60.32 |
| Ash | 3.44 | 3.81 |
| Total | 100.00 | 100.00 |

### OUTPUT, EXPORTS, MARKETS, AND PRICES.

The quantity of kanten prepared in 1900 was 2,370,517 pounds, valued at 1,153,003 yen (or $576,500); and in 1901, 2,177,867 pounds, valued at 1,068,463 yen ($534,232). No later statistics of production are available, but judging from the exports of 1902, the output in that year was apparently larger than ever before, probably reaching 3,000,000 pounds, with a value of $750,000. The exports for a term of years and some detailed statistics of production are shown in the accompanying tables:

*Kanten produced in Hyogo, Kyoto, and Nagano in the years 1897–1901.*

| Town and year. | Quantity. | Value. | Town and year. | Quantity (square pieces). | Value. | Town and year. | Quantity (slender kanten). | Value. |
|---|---|---|---|---|---|---|---|---|
| Hyogo (Muko district): | *Pounds.* | | Hyogo (Kawabe district): | *Number.* | | Hyogo (Kawabe district): | *Pounds.* | |
| 1897 | 265,334 | $60,115 | 1897 | 2,226,667 | $7,345 | 1897 | 7,659 | $1,436 |
| 1898 | 283,867 | 73,395 | 1898 | 2,213,334 | 7,331 | 1898 | 6,934 | 1,560 |
| 1899 | 294,667 | 85,965 | 1899 | 2,346,667 | 7,701 | 1899 | 12,200 | 3,431 |
| 1900 | 317,334 | 83,563 | 1900 | 2,466,667 | 9,300 | 1900 | 15,854 | 7,664 |
| 1901 | 312,000 | 68,450 | 1901 | 2,626,667 | 9,713 | 1901 | 16,800 | 7,805 |

| Town and year. | Quantity. | Value. | Town and year. | Quantity. | Value. |
|---|---|---|---|---|---|
| Kyoto: | *Pounds.* | | Nagano: | *Pounds.* | |
| 1897 | 211,471 | $32,080 | 1897 | 275,012 | $60,770 |
| 1898 | 171,951 | 36,444 | 1898 | 291,307 | 71,358 |
| 1899 | 74,851 | 16,510 | 1899 | 276,891 | 67,249 |
| 1900 | 204,615 | 68,865 | 1900 | 331,480 | 95,305 |
| 1901 | 259,330 | 55,520 | 1901 | 356,305 | 124,106 |

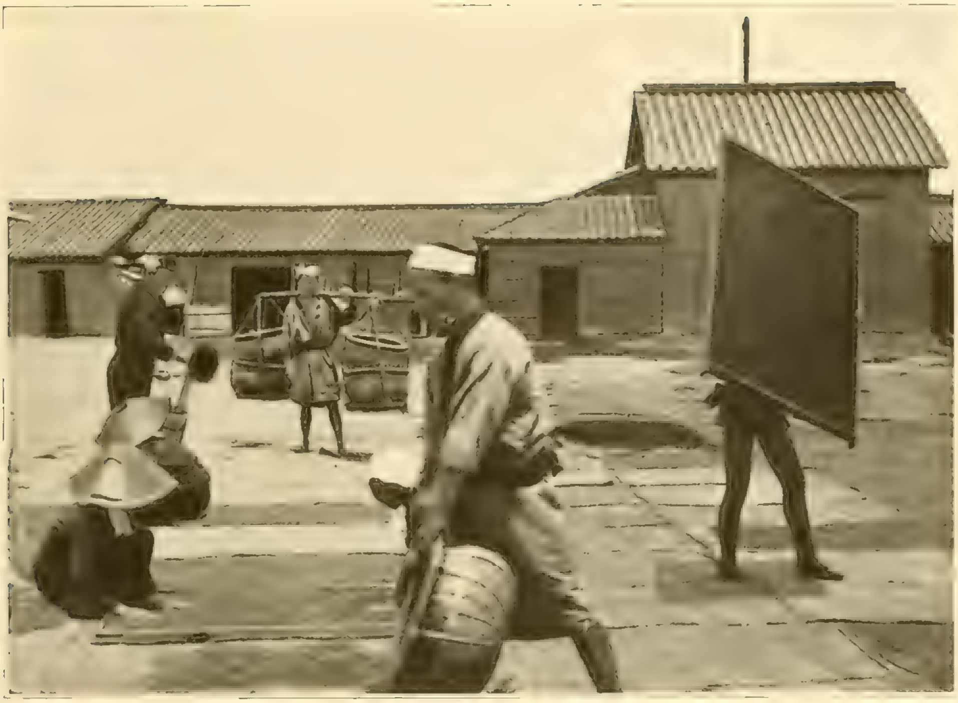
The importance of the kanten industry in Osaka is indicated by the following table, showing an output of over 1,190,000 pounds in 1901:

*Statistics of kanten production in Osaka, 1897 to 1901, inclusive.*

| Year. | Slender kanten. | Square kanten. | Total. |
|---|---|---|---|
| | *Kin.*[a] | *Kin.* | *Kin.* |
| 1897 | 765,000 | 160,125 | 925,125 |
| 1898 | 774,000 | 167,750 | 941,750 |
| 1899 | 810,000 | 172,500 | 982,500 |
| 1900 | 795,000 | 150,938 | 945,938 |
| 1901 | 758,800 | 134,550 | 893,350 |

[a] 1 kin=1.33 pounds.

The exports of kanten during the thirty-four years ending with 1902, as shown in the following table, were 37,196,466 kin (or 49,595,288 pounds), valued at 14,646,910 yen (or $7,323,455). The exports in 1902 were larger than ever before, amounting to 1,655,501 kin (or 2,207,335 pounds), valued at 1,108,544 yen (or $544,272). The average price per 100 kin increased from 29.80 yen (or $14.90) in 1869 to 76.80 yen (or $38.40) in 1901, and 66.60 yen (or $33.30) in 1902.



SPREADING THE WET SEAWEED ON MATS TO BLEACH AND DRY.

VIEW IN THE YARD OF A FUNORI FACTORY IN OSAKA.

THE MANUFACTURE OF FUNORI, OR SEAWEED GLUE.

*Quantity and value of kanten exported.*

| Year. | Quantity. | Value. | Average value per 100 kin. |
|---|---|---|---|
| | *Kin.* | *Yen.* | *Yen.* |
| 1869 | 221,771 | 66,263 | 29.9 |
| 1870 | 272,227 | 98,102 | 36.0 |
| 1871 | 283,606 | 108,387 | 38.2 |
| 1872 | 333,399 | 78,166 | 23.4 |
| 1873 | 364,286 | 102,920 | 28.3 |
| 1874 | 566,384 | 134,243 | 23.7 |
| 1875 | 776,364 | 201,655 | 26.0 |
| 1876 | 1,171,971 | 303,014 | 25.9 |
| 1877 | 1,120,494 | 245,761 | 21.9 |
| 1878 | 1,139,458 | 227,497 | 20.0 |
| 1879 | 1,169,825 | 269,867 | 23.1 |
| 1880 | 1,363,164 | 291,758 | 21.4 |
| 1881 | 1,302,461 | 333,048 | 25.6 |
| 1882 | 777,232 | 211,237 | 27.2 |
| 1883 | 946,606 | 242,405 | 25.6 |
| 1884 | 1,214,286 | 309,084 | 25.5 |
| 1885 | 1,300,802 | 345,719 | 26.6 |
| 1886 | 1,543,350 | 392,644 | 25.4 |
| 1887 | 1,538,064 | 337,879 | 22.0 |
| 1888 | 1,336,790 | 329,222 | 24.6 |
| 1889 | 1,147,713 | 270,511 | 23.6 |
| 1890 | 1,028,500 | 323,444 | 31.4 |
| 1891 | 1,300,237 | 453,124 | 34.8 |
| 1892 | 1,269,200 | 581,218 | 45.8 |
| 1893 | 1,452,725 | 682,140 | 47.0 |
| 1894 | 1,298,425 | 495,625 | 38.2 |
| 1895 | 1,118,775 | 449,271 | 40.2 |
| 1896 | 1,403,125 | 595,818 | 42.5 |
| 1897 | 1,326,900 | 591,057 | 44.5 |
| 1898 | 1,205,906 | 611,336 | 50.7 |
| 1899 | 1,207,275 | 674,435 | 55.9 |
| 1900 | 1,444,500 | 964,322 | 66.8 |
| 1901 | 1,585,144 | 1,217,195 | 76.8 |
| 1902 | 1,665,501 | 1,108,544 | 66.6 |
| Total | 37,196,466 | 13,646,911 | ..... |

1 yen=50 cents.

As will be seen from the foregoing statistics, more kanten is exported than is consumed locally. Slender kanten is sent to China (Shanghai and Hongkong), British India, Australia, Germany, France, and Great Britain; small quantities have also been sold in the United States. The square kanten is exported only to Holland, with which country there has been a trade in this commodity for many years. The prices vary greatly, depending on quality of the product, the shape of the sticks, and the country in which sold. The best quality of square kanten brings as much as 55 or 60 cents a pound, and the best grade of slender kanten 40 cents a pound. The common qualities of the same articles are worth about 40 and 25 cents, respectively, per pound. Following is a detailed statement of the prices of the different grades of kanten in Osaka for a series of years:

*Market prices of kanten per 100 kin.*

| Year. | Best quality. | | Medium quality. | | Common quality. | |
|---|---|---|---|---|---|---|
| | Slender. | Square. | Slender. | Square. | Slender. | Square. |
| | *Yen.* | *Yen.* | *Yen.* | *Yen.* | *Yen.* | *Yen.* |
| 1897 | 55.0 | 115.0 | 48.0 | 98.0 | 43.0 | 85.0 |
| 1898 | [a] 69.0<br>[b] 58.0 | 120.0 | [a] 63.0<br>[b] 55.0 | 105.0 | 49.5 | 90.0 |
| 1899 | [a] 80.0<br>[b] 68.0 | 128.0 | [a] 73.0<br>[b] 63.0 | 115.0 | 57.0 | 100.0 |
| 1900 | | 138.0 | [a] 86.0<br>[b] 80.0 | 125.0 | 71.5 | 110.0 |
| 1901 | [a] 105.0<br>[b] 85.0 | 145.0 | [a] 80.0<br>[b] 80.0 | 130.0 | 65.0 | 113.0 |

[a] For exportation to Europe.

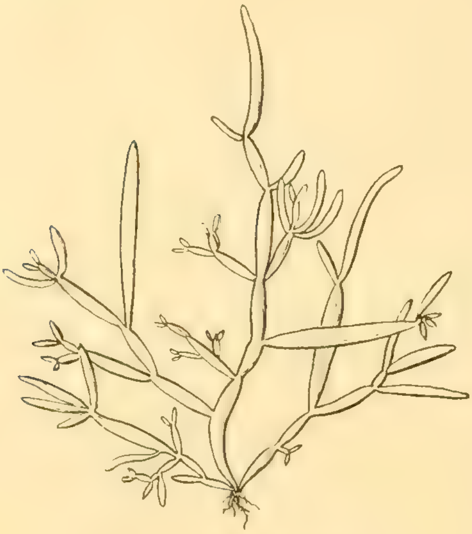
[b] For exportation to China.

## FUNORI, OR SEAWEED GLUE.

### NATURE AND GENERAL IMPORTANCE.

*Funori* is the name given to a kind of glue made from several species of algæ which also are called funori. The word means "material for stiffening fabrics," referring to the most common use of the substance.

The principal funori alga is *Gloiopeltis coliformis*, but *G. intricata* (known as *fukuro-funori*) is probably just as satisfactory. There are, however, various other succulent algæ, belonging to other genera, employed for this purpose, which do not yield so valuable a product as the funori algæ proper. *Gloiopeltis* grows on rocks on all parts of the Japanese coast, but chiefly on the outer (or Pacific) shores of the warmer parts of the Empire. It is gathered at all seasons—in winter in some places, in summer in others—being taken from the rocks by long-handled hooks.

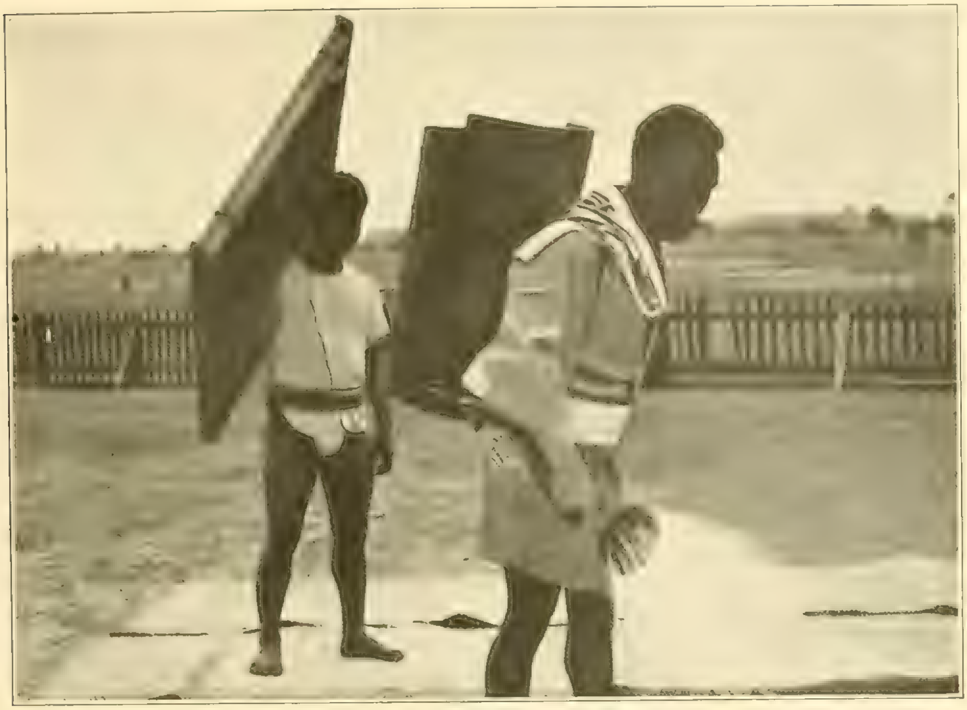

"Funori" (*Gloiopeltis coliformis*).

According to Doctor Kishinouye, there is a limited cultivation of *Gloiopeltis coliformis* in the prefecture of Aomori. The method is quite primitive, consisting simply of throwing stones into the sea to afford a surface for the attachment and growth of the spores. As the stones of the mountains have rough, clean surfaces, they are preferred to others.

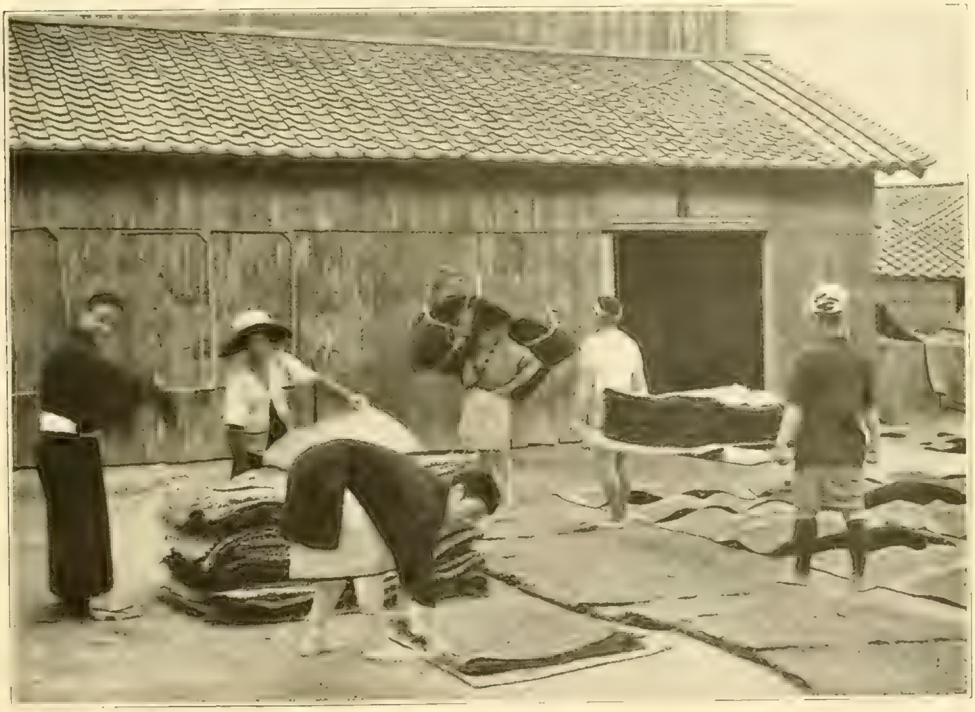
While the manufacture of funori is less extensive than that of kanten or kombu, it is nevertheless quite important, being carried on in over 100 establishments, each employing from 15 to 20 persons, located in about 30 different prefectures, the most northern being Hokkaido and the most southern Kagoshima. The industry flourishes most in southern Japan, and Osaka is the principal center. Funori has been made in Japan since about the year 1673.

### THE PREPARATION AND APPLICATIONS OF FUNORI.

The process of converting the raw seaweed into the marketable product is much simpler than in the case of kanten or kombu. The dried algæ, as received from the fishermen, are first sorted and cleaned, and then soaked in fresh water, after which they are usually placed in thin layers on large shallow trays with reed or bamboo bottom, and tightly packed by hand so as to form a loose sheet. The sheets are then turned out on pieces of matting by inverting the trays, and are left to bleach and dry. Sometimes, however, the sheets are made directly on the mats without the use of trays. A tendency to curl in drying is overcome by sprinkling with a watering pot or a wet broom. When bleaching has proceeded as far as desirable, the drying is completed and the funori sheets are gathered in bundles of various sizes. The sheets are loose meshed, thin, flexible, and of quite uniform thickness. The usual



SPRINKLING THE SHEETS TO PREVENT CURLING.

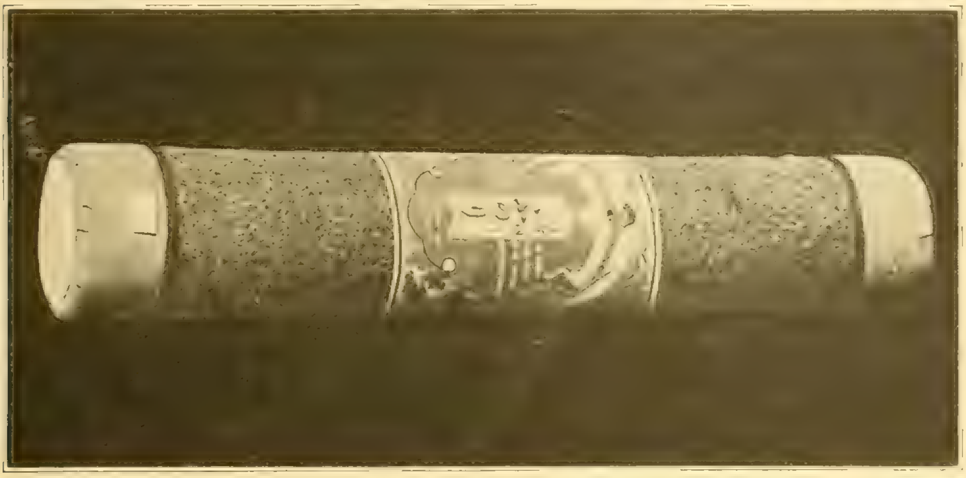


GATHERING THE DRIED SHEETS FOR BALING AND SHIPMENT.

THE MANUFACTURE OF FUNORI, OR SEAWEED GLUE.

size is about 5 by 3 feet, but smaller sheets in neat packages are prepared for the retail trade. A favorite form of package for the wholesale trade is a roll 3 feet high and 6 or 7 inches in diameter, like Japanese matting.

Funori is readily converted into a glue or paste by immersion in boiling fresh water, and in that form is extensively used in Japan, and small quantities are exported. The principal objects for which it is employed are the glazing and stiffening of fabrics, its most common use being as a starch for clothing. Other uses are the stiffening and coating of papers, the cementing of walls and tiles, the stiffening of threads, and the decorating of porcelain. The funori sent to Europe is for sizing textiles. Japanese women sometimes clean their hair with a thin solution, although the rationale of the operation is not evident.


A roll of funori (about one-eighth natural size).

### PRICES AND OUTPUT.

The price of funori varies with the quality. The purest grade sold (in 1903) for 40 yen per 10 kwan, wholesale, or at the rate of 24 cents a pound; the medium quality brought 18 yen per 10 kwan (11 cents a pound), and the poorest grades, made from substitutes for *Gloiopeltis*, were worth only 5 or 6 yen per 10 kwan (3 to 3.6 cents a pound). The production during recent years has been from 2 to 3 million pounds annually; in 1901 it was 2,943,000 pounds. The following table shows the amount and value of the output between 1897 and 1901:

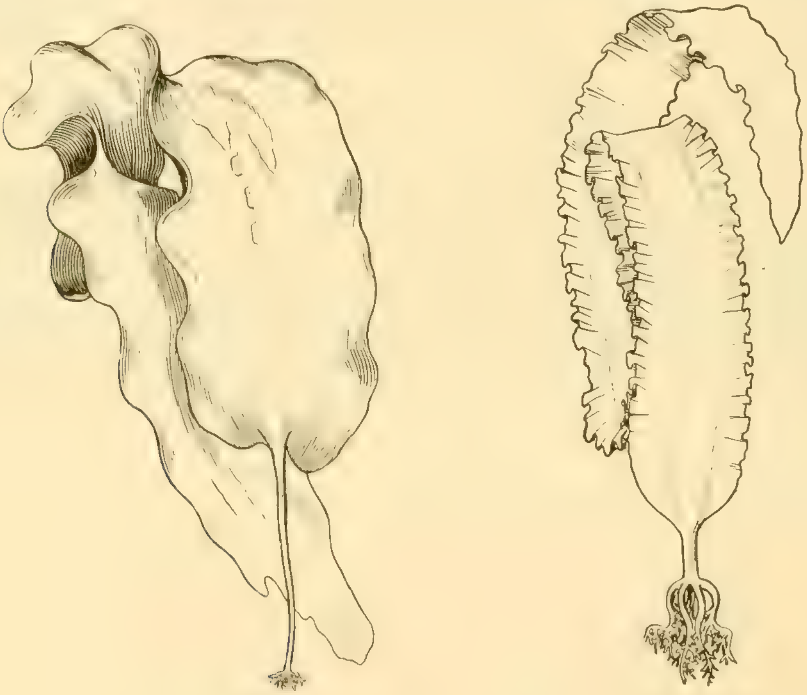
| Year. | Quantity. | Value. |
|---|---|---|
| | *Pounds* | |
| 1897 | 1.429.111 | $53.857 |
| 1898 | 987.862 | 41.478 |
| 1899 | 2.799.253 | 115.326 |
| 1900 | 2.135.677 | 77.033 |
| 1901 | 2.943.383 | 130.809 |

The exportation of funori is a small business, the shipments at the present time being valued at only $1,500, although they have at times reached $3,300. The countries supplied are Korea, China, Asiatic Russia, Russia, England, and France.

## KOMBU.

### NATURE AND GENERAL IMPORTANCE.

Under the name of *kombu* the Japanese recognize various kinds of food made from kelps. This is one of the most important of the marine vegetable preparations, the annual sales in Japan and China being enormous and steadily increasing, especially in China. Some of the products have occasionally been sent to the East Indies and San Francisco; but the sales in America are reported to have been small, and it may be said that kombu is as yet unknown outside of Asia. Although not so valuable as kanten, it is really more important to the country, because of its comparative cheapness and the numerous ways in which it is used for food; furthermore, the gathering of kelp gives employment to more people than does the gathering of *Gelidium*, and the value of the raw products exceeds that of any other kind of seaweed.



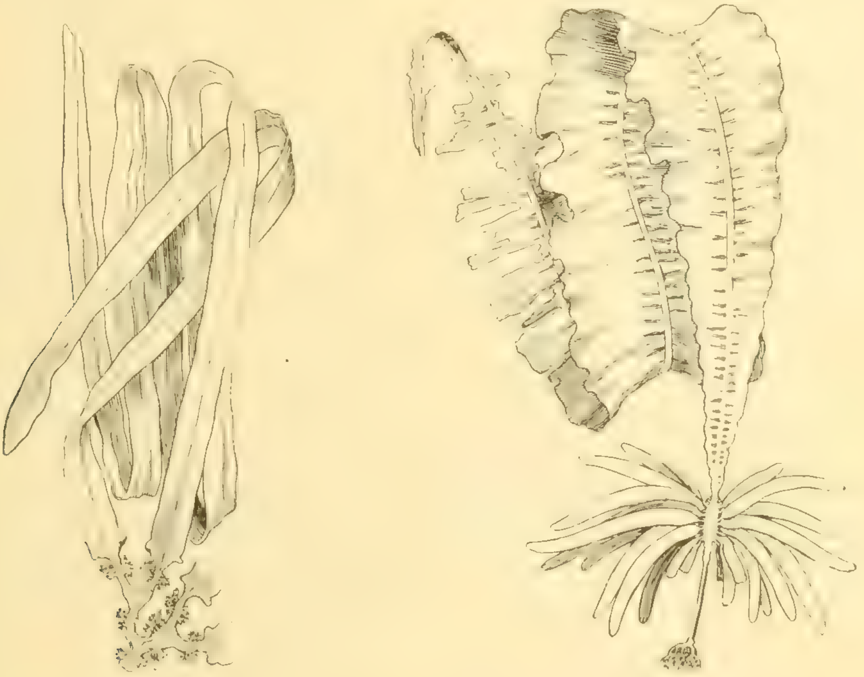
*Laminaria longipedalis.* *Laminaria japonica.*

Kelps used in preparing kombu.

The manufacture of kombu dates back to about 1730. The present methods are very primitive, and differ but little from those of the eighteenth century. The principal centers are Osaka, Tokyo, and Hakodate, the leading place being Osaka, where in 1903 there were 45 small factories, each employing from 10 to 30 men, women, and children.

### THE RAW PRODUCTS.

The seaweeds used in the manufacture of kombu are coarse, broad-fronded members of the kelp family (Laminariaceæ), and are obtained almost entirely from Hokkaido, the most northern of the main islands of the Japanese archipelago. The kelps grow in abundance on all parts of that coast, but those of best quality—that is, with the widest and thickest fronds—are obtained from the northeastern coast, within the influence of the Arctic current. Those most used are of the numerically large genus *Laminaria*, and include the species *japonica*, *religiosa*, *angustata*, *longissima*, *ochotensis*, *yezoensis*, *fragilis*, *diabolica*, *gyrata*, and several others recently described by Professors Miyabé and Oshima. Other kelps which are utilized in kombu manufacture are *Arthrothamnus bifidus* and *kurilensis*, *Alaria fistulosa*, and various other species of *Alaria*.



*Arthrothamnus bifidus.* *Alaria crassifolia.*

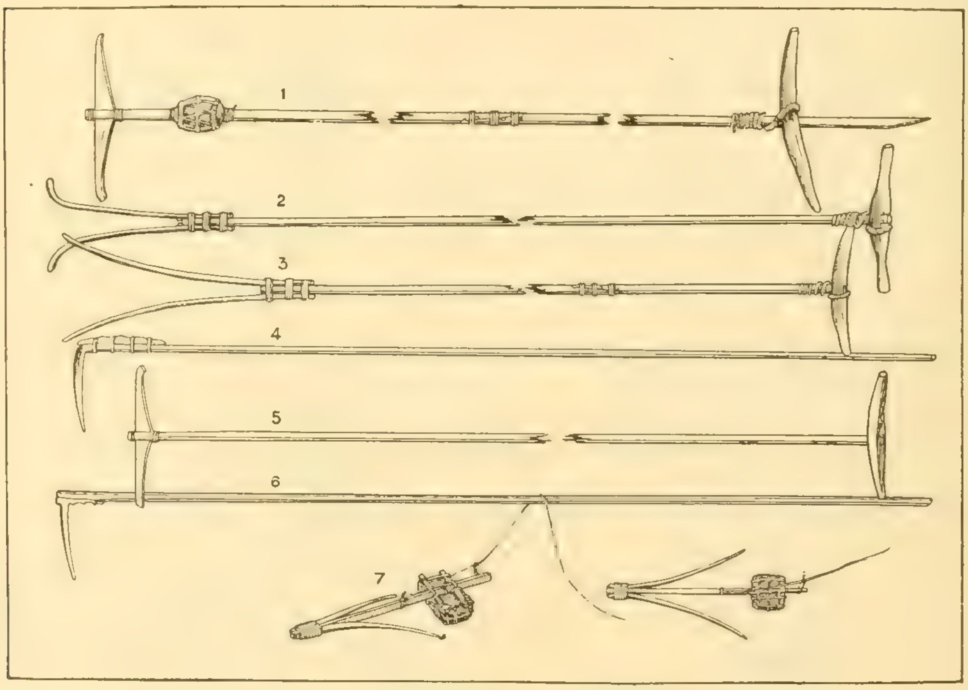
Kelps used in preparing kombu.

The gathering of kelp begins in July and ends in October, and is engaged in by many fishermen, among whom may be found some Ainus, the peculiar aboriginal inhabitants of Japan now confined to Hokkaido. The fishermen go to the kelp grounds in open boats, each boat with one to three men and a complement of hooks with which the kelp is torn or twisted from its strong attachment on the rocky bottom. The hooks are of various patterns; some are attached to long wooden handles, and some are weighted and dragged on the bottom by means of ropes while the boats are under way.

When the boats return to shore the kelp is carefully spread on the beaches in the vicinity of the villages and there left until thoroughly dried. The curing accomplished, the plants are taken indoors and prepared for shipment. The stem is cut off, and at the same time the basal end of the frond is neatly trimmed. Plants of the same size and quality are tied together into long flat bundles of rather uniform size, and these bundles are sent by water to the kombu manufacturers.

### KOMBU PREPARATIONS.

The forms in which kombu is made ready for consumption number a dozen or more, and illustrate the ingenuity of the Japanese in providing a varied regimen from a single article. Some of the preparations are not pleasing to the taste of the average foreigner, but others are highly palatable and ought to prove very acceptable to Americans and Europeans.



Forms of hooks used in gathering kelp in Hokkaido.

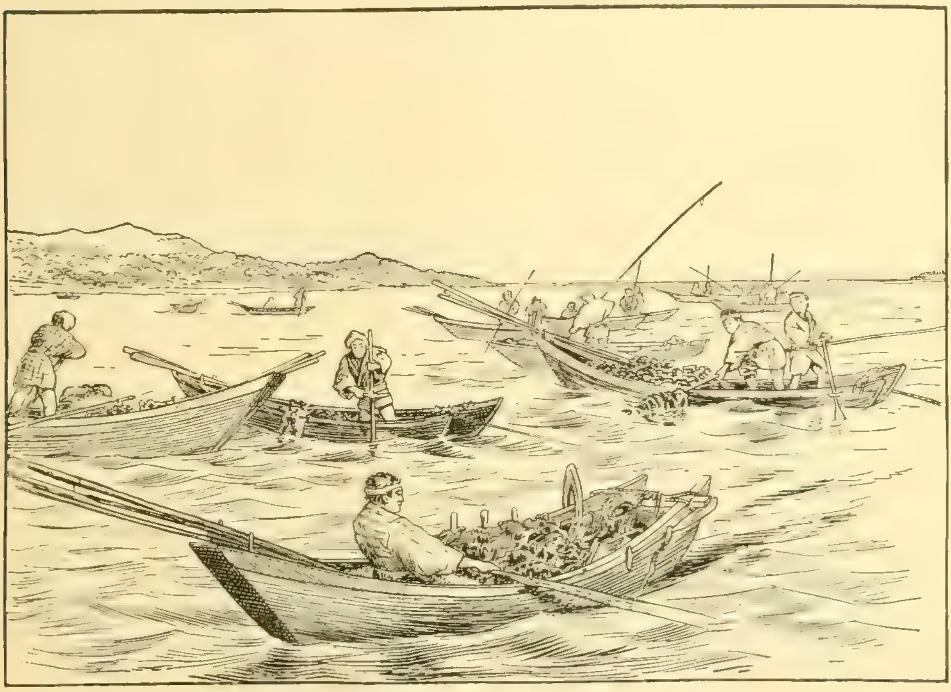
*Shredded or sliced* (*kizami*) *or green-dyed* (*ao*) *kombu.*—This is one of the most important preparations of kombu, being largely consumed at home and also extensively exported. The steps in the manufacture are as follows:

(1) The dried kelp, as received in bundles from the Hokkaido fishermen, is immersed in large, covered, stationary iron kettles or vats containing a strong solution of a dye in fresh water. A wood fire is kept under the kettles, and the solution is maintained at a boiling temperature, the kelp being left therein for fifteen to twenty minutes and stirred from time to time. The dyeing imparts a uniform color to the prepared product as placed on the market, and thus serves the same purpose as the dyeing of canned French peas. Formerly a copper salt (carbonate or

sulphate) was employed, but the use of copper in this way has recently been prohibited by the government, and an aniline dye (malachite green) is now employed, although the latter is regarded with less favor by the manufacturers. The kelp is thoroughly cooked, and is saturated with the dye, which remains insoluble.

(2) The dyed fronds are drained and then taken into the open air, where they are either spread on straw mats or suspended on poles to dry. In order to economize space, a tier of horizontal poles covered with kelp may be placed between two upright poles, and in the yards of many of the kombu works the lines of freshly dyed kelp may be seen high in the air.

(3) When the drying has proceeded to a point where the surface of the kelp is no longer wet, the fronds, taken one at a time and carefully spread, are rolled into wheel-shaped masses about 1 foot in diameter, in order to facilitate subsequent handling. The rolls are tied by ropes to keep them in shape, and then go to women, who unroll the fronds one by one and arrange them flat in wooden frames, making a pile 1½ feet high, 5 or 6 inches wide, and the full length of the fronds. Each pile is then tightly compressed by four transverse cords, and cut by means of a knife into four equal lengths, each held by a cord.

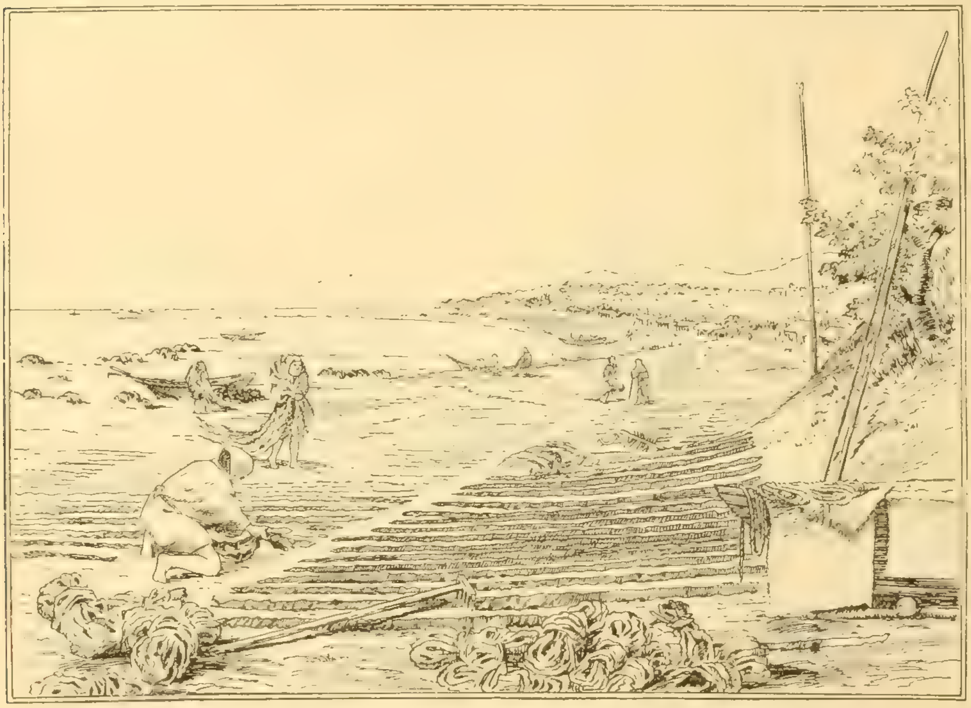


Kelp fishermen of Hokkaido.

(4) The cut pieces are then arranged by hand in a rectangular frame 4 to 5 feet square, its thickness corresponding to the length of the sections of seaweed. When the frame is filled by the evenly arranged pieces, which are sprinkled with water in order that they may pack more closely, the whole mass is highly compressed by

means of ropes, wedges, and levers. One of the side boards forming the frame is then removed, the frame is supported at a convenient height and tilted at a convenient angle, and the kelp is reduced to shreds by means of a hand plane, which cuts the fronds lengthwise along their edge. A factory has from 5 to 10 cutters, each with a separate press, and each using his plane in what to us seems an awkward manner—that is, he cuts by drawing the plane toward himself rather than by pushing it from him. Formerly the cutting was done with a knife held in the hand. The substitution of a plane, by which shreds of more uniform thickness are obtained and the work done more expeditiously, is practically the only improvement in method in nearly two centuries.

(5) The shredded kelp is spread on mats or on board platforms in the open air, and repeatedly turned to secure uniform drying. When the surface has become dry, but the interior still retains its moisture as shown by the pliability of the shreds, the shavings are stored under cover and are ready for packing and shipment.

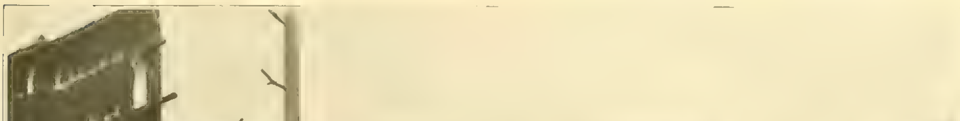


Drying kelp on the beach in Hokkaido.

The completed product resembles in color, shape, and feel the "Spanish moss" which festoons the trees in the Southern States. For local use it is put in paper packages, for export to China in wooden boxes. If dry it will keep for a year or longer without deterioration.

*Other kombu preparations.*—Those species of kelp with the thickest and widest fronds are often dried with special care, so that they will lie flat and smooth, and are used in making kombu products for which the thin, narrow-fronded species are not well adapted. The different kinds of kombu now to be mentioned have been

WOMEN ENGAGED IN SORTING THE CRUDE KELP.

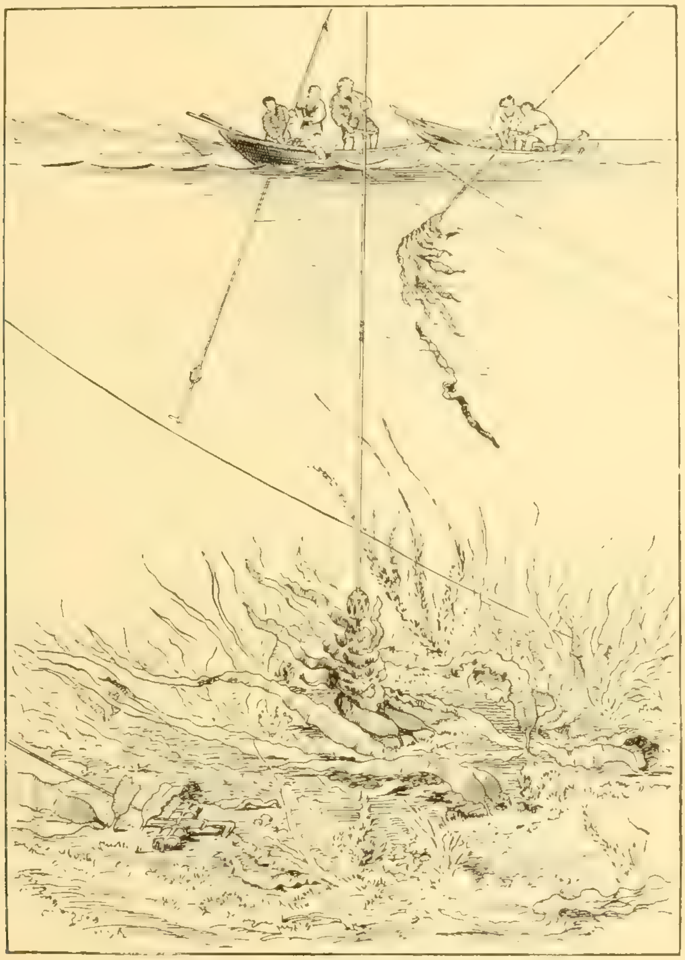


DYED KELP DRYING ON POLES; SHREDDED KOMBU DRYING ON MATS AND READY FOR BALING.

VIEWS AT AN OSAKA KOMBU FACTORY.

made for nearly two centuries, and the consumption at the present time is larger than ever before. The various grades, as will be seen, represent simply successive steps in the treatment of the kelp, one frond yielding a sample of each variety of kombu.

(*a*) The entire frond is dipped in vinegar until thoroughly soaked, then drained and dried in the open air. The vinegar used is of Japanese make and of the best quality, and is diluted with a very little water. The vinegar softens the frond and leaves it pliable; it also imparts a flavor and doubtless has a slight preserving effect. Its chief supposed or intended action, however, is to permit the special treatment which will be described. Fresh water would have the same softening effect, but would spoil the seaweed for the purpose in view.



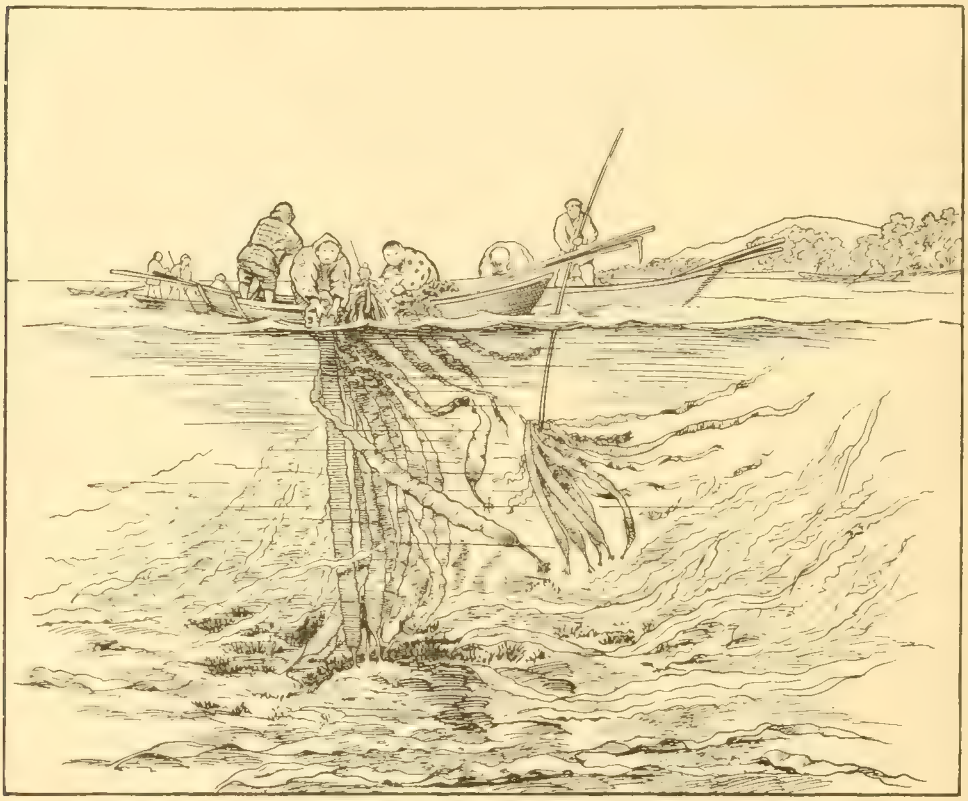
Gathering kelp with poles and drags.

(*b*) With a raw-edged knife shaped like a mince-meat chopper, the Japanese artisan, holding the broad frond taut with hand and foot, scrapes the epidermis from both sides. This outer skin, which comes away in shreds, is the cheapest grade of kombu, containing more or less grit or dirt. A second scraping brings away all of the remaining green covering, and leaves only the thick white core of the frond. This product is called *kuro-tororo* (black pulpy) kombu.

(*c*) The scraping is continued with a raw-edged knife, and a fine, white, stringy mass results, which is known as *shiro-tororo* (white pulpy) kombu.

(*d*) A sharp-edged knife may be used after the green coats are removed, and the scrapings then take the form of exceedingly thin and delicate filmy sheets of irregular sizes; this preparation is named *oboro* (filmy) kombu.

(*e*) The remaining central band of the frond, now very thin and no longer workable in this way, is pressed into bundles with similar pieces, divided into equal lengths, and with a plane cut edgewise into shreds after the manner of the green-dyed kombu. The shavings resemble coarse hair, and the preparation has received a name (*shirago kombu*) which means white-hair kombu.



Gathering kelp.

(*f*) Fronds from which the outer green skin has been more or less completely scraped are often cut into small pieces of various shape—strips, squares, oblongs, circles, fans, etc.—which are then dried over a fire and made crisp; the long strips are frequently tied into peculiar loose knots. These pieces are placed on the market in this form, when they are known as *hoiro* (dried-on-the-fire) kombu; or they are coated with a hard white or pink icing and called *kwashi* (sweet-cake) kombu.

(*g*) The dried pieces just mentioned are sometimes pulverized and put through a fine wire sieve like a flour sieve, yielding a slightly greenish or grayish flour. A white and still finer powder is made from the deeper layers of the frond. The powdered preparations are named *saimatsu* (finely powdered) kombu. Such powders are sometimes compressed into small cakes of various shapes and coated with sugar.

(*h*) A form of kombu known as *cha* (tea) kombu is prepared by taking fronds which have been subjected to the first scraping process, reducing them to shreds in the usual way by planing and, after drying, cutting the shreds into half-inch lengths comparable to the rolled leaves of green tea.

## FOOD QUALITIES OF KOMBU.

Kombu enters into the dietary of every Japanese family, and is one of the standard foods of the country, the various preparations having different flavors and being used for different purposes. The green-dyed and shredded kombu is cooked with meats, soups, etc., and is also served as a vegetable. Strips of the dried untreated fronds are cooked with soups, fish, and vegetables, for the purpose of imparting a flavor. Fronds after being scraped once are cut in ¾-inch squares and boiled in soy-bean sauce, which treatment preserves them for a long time, and these pieces make an excellent relish, tasting like caviare or anchovy sauce. The Japanese name, *tsukudani*, means "boiled with soy-bean sauce." The tea kombu and the green and white powdered kombu are used as tea, boiling water being poured on a small quantity of the preparation and a palatable drink resulting. In Osaka the pulpy or pasty residue is eaten. The powders are also used in sauces, in soups, and on rice, like curry powder. These are put on the market in bottles or tins holding about one-quarter of a pound.

The kombu cut into small pieces and dried is very palatable, whether eaten dry or after immersion in hot water, having a nutty flavor. The crisp, sugared strips are excellent. Filmy sheet kombu is cooked with sauces, soups, and other dishes, like the dried, untreated strips, to impart flavor.

The chemical composition of various species of seaweed used in the manufacture of kombu is shown in the following table. The specimens were collected in the Sea of Hokkaido, and the analyses were made by Prof. K. Oshima, of the Agricultural College of Sapporo. The figures are calculated for 100 parts of original samples of kombu:

| Species. | Water. | Protein. | Fat. | Soluble non-nitrogenous matter. | Fiber. | Ash. |
|---|---|---|---|---|---|---|
| | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Laminaria angustata | 22.823 | 5.491 | 1.520 | 47.031 | 4.549 | 18.686 |
| longissima | 25.944 | 6.724 | 1.730 | 31.896 | 6.415 | 27.290 |
| japonica | 22.968 | 4.959 | 1.590 | 47.493 | 5.834 | 17.156 |
| ochotensis | 23.986 | 6.646 | .860 | 41.924 | 6.026 | 20.308 |
| religiosa | 22.754 | 4.722 | .820 | 42.845 | 10.196 | 18.633 |
| fragilis | 23.100 | 4.027 | .654 | 40.385 | 7.152 | 24.682 |
| Arthrothamnus bifidus | 24.443 | 5.822 | .738 | 45.572 | 6.437 | 16.988 |

### OUTPUT AND PRICES OF KOMBU.

Official figures are available showing the quantity and value of the kelp gathered, dried, and sold by the fishermen during recent years. In 1901 the output was over 76,000,000 pounds, for which the fishermen received $464,000.

| Year. | Pounds. | Value. |
|---|---|---|
| 1901 | 76,806,975 | $464,082 |
| 1900 | 53,750,650 | 301,389 |
| 1899 | 68,929,984 | 417,332 |

There appear to be no statistics of the quantity and value of prepared kombu put on the maket, but the addition of 60 to 75 per cent to the cost of the raw materials would doubtless approximate the value of the manufactured article.

In Osaka the output of green-dyed kombu in 1902 was as follows: For home consumption, 4,728,640 pounds; for export to China, 7,092,960 pounds; total, 11,821,600 pounds, valued at $132,968. The operations of one Osaka manufacturer in 1902 are represented by raw materials used, 9,900 bushels, costing $4,950; green-dyed kombu made, 600,000 pounds, valued at $8,550.

Following are the average wholesale prices of the various kinds of kombu in Osaka in 1903: Green-dyed kombu, good quality, 5 yen per 100 kin (133 pounds); black pulpy kombu, from 0.35 yen for cheapest to 0.70 yen for best per kamme (8.28 pounds); white pulpy kombu, from 0.80 yen for cheapest to 1.10 yen for best per kamme; white hair kombu, from 0.50 yen for cheapest to 0.80 yen for best per kamme; finely powdered kombu, 2 yen per kamme; filmy kombu, from 0.60 yen for cheapest to 1.30 yen for best per kamme; tea kombu, 1.20 yen per kamme; kombu chips (dried on fire), from 1.80 yen to 2.40 yen per kamme; sweet cake kombu, from 1.50 yen to 1.80 yen per kamme; kombu chips in soy sauce, 1.10 yen per kamme. The powdered kombu sells at wholesale for 0.08 yen per quarter-pound tins, and 0.10 yen for quarter-pound bottles.

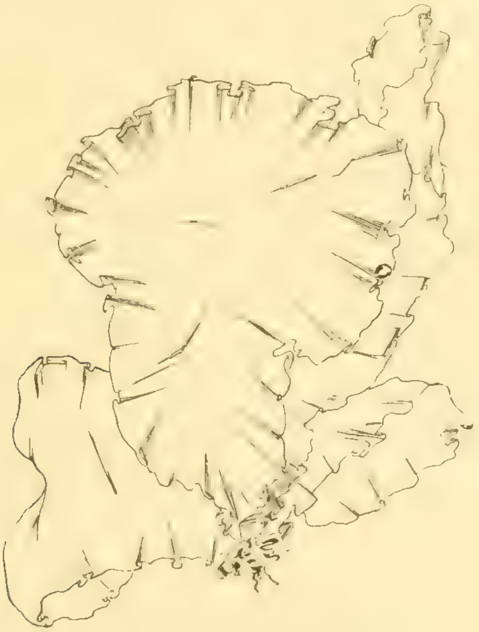
A very large part of the supply of green-dyed kombu is exported to China. Official figures of the quantity and value of the exports for the eleven years ending in 1902 are here given. It appears that in 1901 the foreign trade was larger than in any previous year, the shipments exceeding 81,000,000 pounds.

| Year. | Pounds. | Value. | Year. | Pounds. | Value. |
|---|---|---|---|---|---|
| 1892 | 57,115,460 | $437,413 | 1898 | 56,031,761 | $355,646 |
| 1893 | 52,871,341 | 469,710 | 1899 | 61,596,504 | 473,041 |
| 1894 | 55,800,505 | 505,514 | 1900 | 48,054,681 | 441,864 |
| 1895 | 49,775,318 | 515,146 | 1901 | 81,212,970 | 774,164 |
| 1896 | 46,533,772 | 504,792 | 1902 | 52,491,160 | 404,744 |
| 1897 | 60,153,105 | 415,732 | | | |

## AMANORI OR LAVER.

### THE SEAWEEDS AND THEIR CULTIVATION.

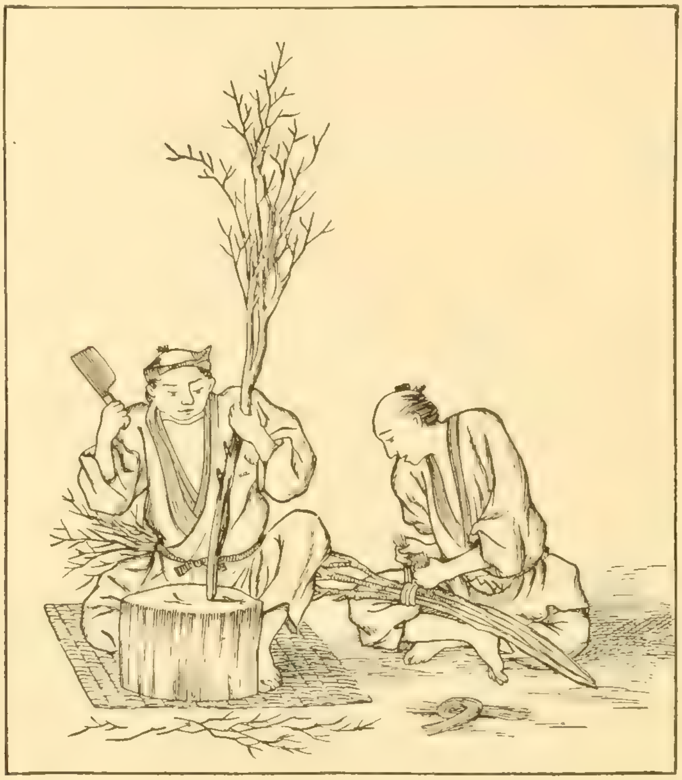
The Japanese have from a very early period made use of the red laver (*Porphyra*), formerly a popular food in the British Isles and sparingly eaten in the United States. The Japanese species is similar to or identical with that found in Europe and America (*Porphyra laciniata* or *vulgaris*), and grows abundantly in bays and near river mouths on all parts of the coast, but the supply is obtained almost exclusively from cultivated grounds. The local name for the seaweed is *amanori*, while the prepared product is called *asakusanori*. The following description of the species has been given:


"Amanori" or laver (*Porphyra laciniata*).

> Fronds livid purple, gelatinous, but firm, membranaceous, composed of a single layer of brownish-red cells; fronds 3 inches to 1½ feet long, persistent throughout the year, at first linear, but becoming widely expanded and finally much lobed and laciniate; antheridia and spores forming a marginal zone, usually borne on different individuals, or when borne on the same individual not mixed, but on separate portions of the frond. Found in all parts of the world; abounds on rather smooth stones and pebbles, near low-water mark, and when the tide falls covers them with slimy films, which make walking over them difficult. (FARLOW.)

The cultivation of *Porphyra* is one of the most important branches of the seaweed industry, and gives to Japan a unique position, for, so far as known to the writer, in no other country is this form of aquiculture practiced. The financial results are quite remarkable, and are surpassed by but few branches of agriculture, comparing the average yield per acre.

The date of the beginning of seaweed culture has not been determined, but the business is known to be very old and probably began in Tokyo Bay, which has long had the most celebrated cultivated grounds. The next important point is Hiroshima, on the Inland Sea. The Japanese government collects very accurate statistics of this industry, and has furnished the accompanying data showing the area of the laver farms, the annual crop, etc. In 1901, the grounds under cultivation had an area of 2,242 acres, and the output was valued at $239,536, representing about 4,769,000 pounds of dried seaweed.


Preparing brush for laver cultivation.

*Porphyra cultivation in 1901.*

| Prefecture. | Grounds. |  | Yield. |  |
|---|---|---|---|---|
|  | Number. | Area (tsubo).[a] | Quantity (kamme)[b]. | Value (yen). |
| Tokyo | [c]3,493 | 1,151,314 | 37,478 | 297,723 |
| Kanagaw | 1 | 7,120 | 98 | 345 |
| Aichi | 12 | 221,800 | 30,250 | 15,527 |
| Iwate | 14 | 185,743 | 7,715 | 7,466 |
| Hiroshima | 846 | 589,627 | [d]376,700 | 126,015 |
| Yamaguchi | 6 | 147,800 | 8,154 | 4,514 |
| Wakayama | 2 | 43,027 | 105,000 | 16,800 |
| Ehime | 2 | 600 | 350 | 160 |
| Fukuoka | 7 | 147,800 | 485 | 1,996 |
| Oita | 2 | 3,600 | [e]78,820 | 394 |
| Kumamoto | 2 | 74,000 | 5,949 | 7,019 |
| Kagoshima | 8 | 140,000 | 890 | 1,113 |
| Total | 4,395 | 2,712,431 |  | 479,072 |

---

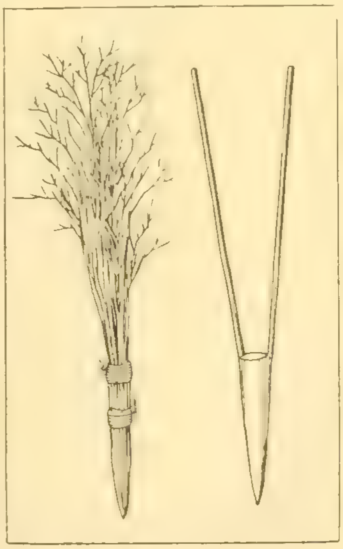
[a] A tsubo=4 square yards. [b] A kamme=8.28 pounds. [c] Number of families of fishermen. [d] Fresh plants. [e] Number of sheets of prepared *Porphyra*.

The following more detailed statistics show the extent of this industry in the Tokyo region during three years. In 1901 the area of the planted grounds was 951.5 acres, and the value of the crop was $148,862, or about $156 per acre. It is reported that in 1903 the yield was valued at 600,000 yen ($300,000).

*Porphyra cultivation in Tokyo Bay.*

| Year and district. | Families of fishermen. | Area of grounds. | Crop. | |
|---|---|---|---|---|
| | | | Quantity. | Value. |
| 1899. | | *Tsubo.* | *Kamme.* | *Yen.* |
| Shiba | 160 | .......... | 1,010 | 6,000 |
| Fukagawa | 161 | .......... | 6,602 | 38,718 |
| Kyobashi | 5 | .......... | 5 | 62 |
| Ebara | 2,063 | .......... | 15,717 | 98,500 |
| Minami Katsushika | 837 | .......... | 10,467 | 104,662 |
| Nishitama | 1 | .......... | 16 | 2,000 |
| Total | 3,227 | .......... | 33,817 | 249,942 |
| 1900. | | | | |
| Shiba | 153 | 113,880 | 6,670 | 50,100 |
| Fukagawa | 161 | 223,500 | 2,986 | 29,860 |
| Kyobashi | 9 | 10,000 | 40 | 620 |
| Ebara | 2,028 | 771,047 | 17,696 | 136,798 |
| Minami Katsushika | 837 | 93,969 | 5,382 | 33,641 |
| Total | 3,188 | 1,212,396 | 32,776 | 251,019 |
| 1901. | | | | |
| Shiba | 99 | 127,800 | 4,360 | 26,700 |
| Fukagawa | 476 | 123,083 | 4,479 | 31,432 |
| Kyobashi | 6 | 15,900 | 810 | 7,482 |
| Ebara | 2,030 | 781,965 | 12,336 | 107,940 |
| Minami Katsushika | 883 | 102,566 | 15,489 | 123,809 |
| Total | 3,493 | 1,151,314 | 37,474 | 297,723 |

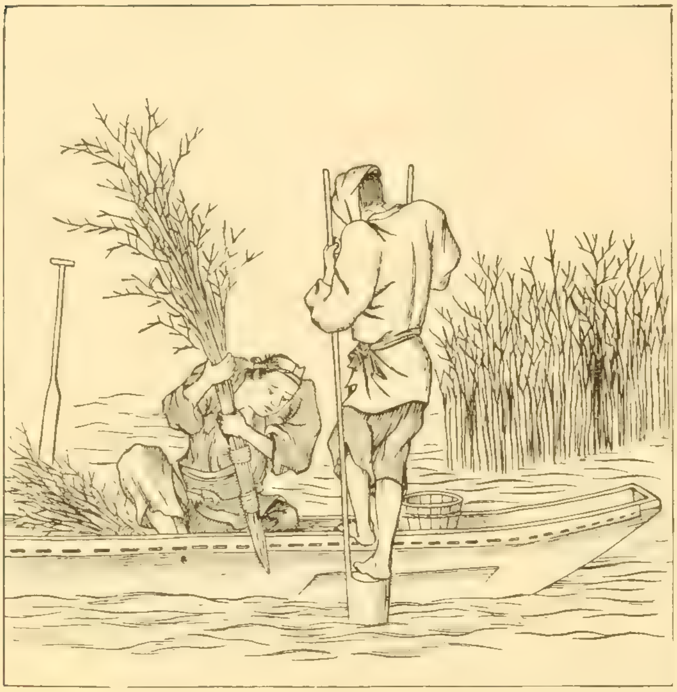
In October and November (in Tokyo Bay) the grounds are prepared for the seaweed crop by sinking into the muddy bottom, in water up to 10 or 15 feet deep at high tide, numerous bundles of bamboo or brush. These bundles are prepared on shore and taken to the grounds in boats at low tide, one or two men constituting a boat's crew. The bundles of brush are planted in regular lines, deep holes being made for them by means of an elongated conical wooden frame with two long, upright handles, which is forced into the mud by the weight of the fisherman.



Bundle of brush and conical frame used in planting brush on soft bottom.

The object of these lines of brush is to intercept and afford a lodgment for the floating spores of *Porphyra*. The spores become attached to the twigs and grow rapidly, so that by the following January the plants have attained full size and are harvested from January to March, being cut from the brush as they grow. They die about the time of the vernal equinox, and the active business is at a standstill until the ensuing fall. During summer, however, the old brush is removed from the grounds, and fresh material is collected and prepared.

The best grounds for growing *Porphyra* are in great demand, and the fishermen are often in conflict over them. The local

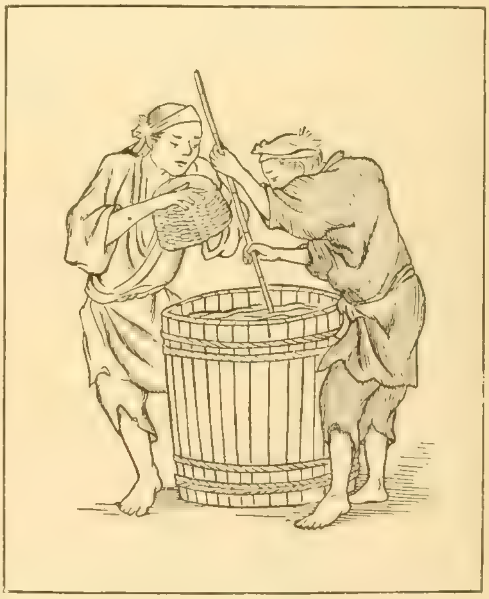

Planting bundles of brush on which laver is to grow.

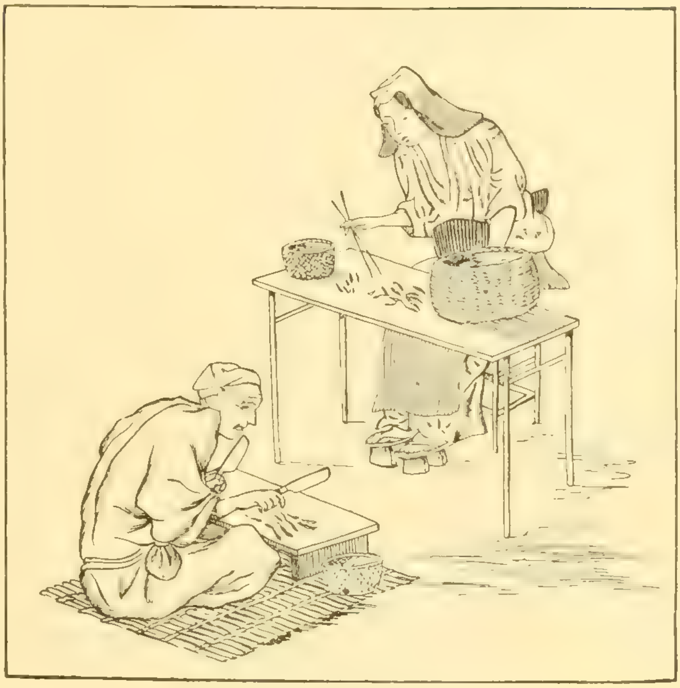
governments lease the planting privileges. In Tokyo, where five classes of licenses are issued, depending on the yield of the grounds, the license tax is from 0.20 to 0.70 yen.

It is reported that the quality of the cultivated *Porphyra* depends very much on the weather, and is best when frequent rains and falls of snow have rendered the shallow water more or less brackish. Too large a proportion of sweet water is unfavorable to the growth of the plant. A century or two ago amanori was gathered in large quantities at the mouth of the Sumidagawa, near Asakusa in Tokyo; but as the river carried down with it a large quantity of gravel, its mouth advanced more and more into the sea, and, the water near Asakusa becoming too fresh, the plant disappeared. Owing to this circumstance, the above-described mode of cultivation was instituted. The plant has, however, preserved its former name of *Asakusa-nori*.

### PREPARATION AND UTILIZATION OF PORPHYRA.

While small quantities of amanori are eaten fresh, most of the crop is sun-dried before reaching the consumer. When gathered from the twigs, the seaweeds contain sand, mud, and other foreign substances, to remove which they are washed in tanks or barrels of fresh water. After being picked and sorted they are chopped fine with hand knives. The chopped fronds are then spread on small mats of fine bamboo splints and made into thin sheets, a uniform size being attained by means of a frame applied to the mats. The mats are first placed

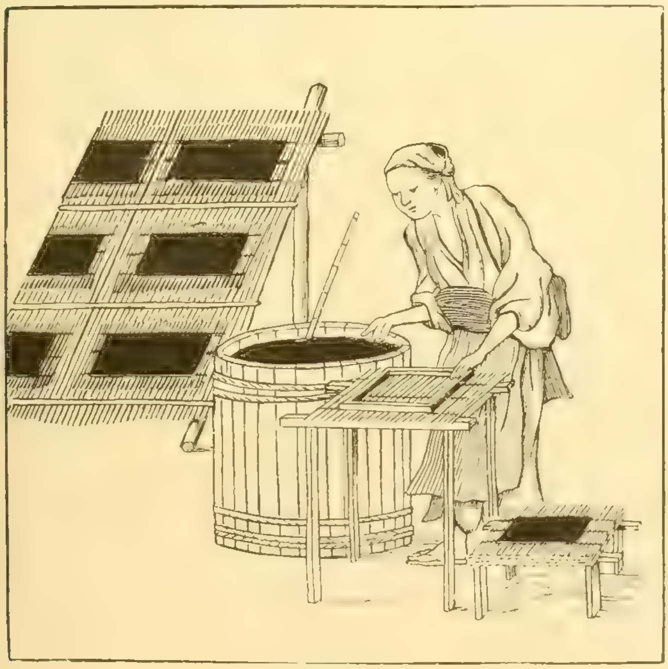

Washing laver prior to sorting and cutting.



Sorting and cutting laver.

in piles and later spread on inclined frames in the open air. Drying proceeds quickly, and when completed the sheets are stripped from the mats and, after pressing to make them flat, are arranged for market in bundles of ten. The sheets are about 10 by 14 inches, thin and flexible like writing paper, and have a dark mottled brownish-purple color and a glossy surface.

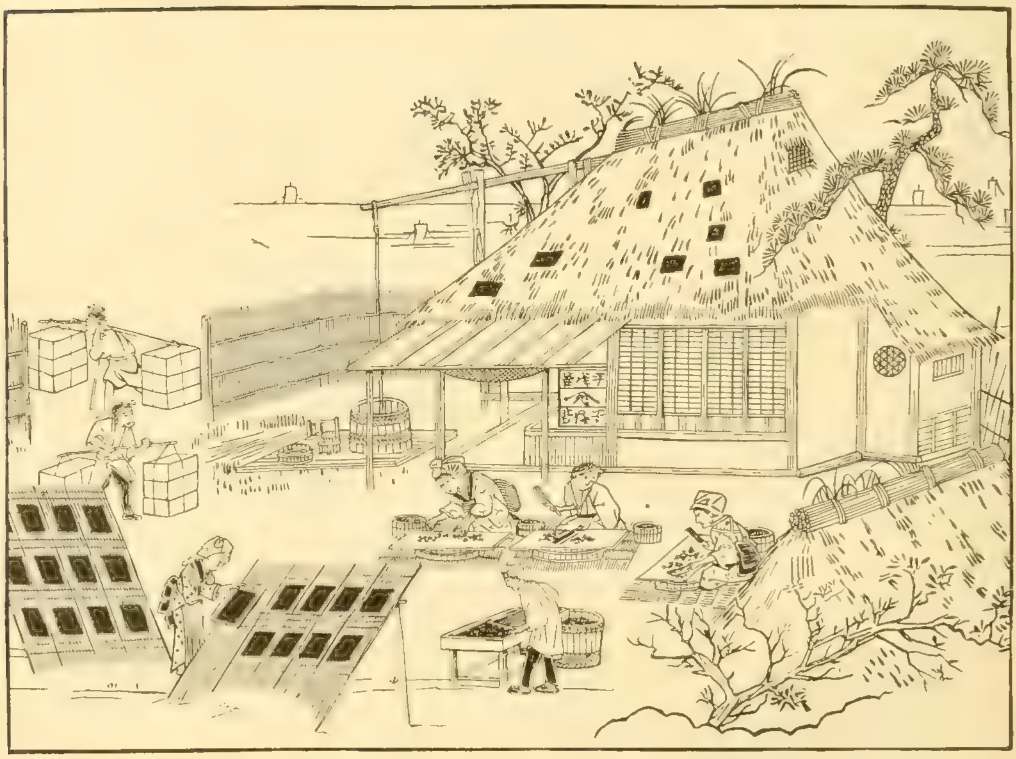
Before the dried *Porphyra* is eaten it is put over a fire to make it crisp, its color changing to green under this treatment. It is then crushed between the hands and dropped into sauces, soups, or broths to impart flavor. Pieces dipped in sauce are also eaten alone and there are various other culinary uses of this article, which is found in every Japanese kitchen. Recently it has been boiled with Japanese (soy bean) sauce and put up in tins. At railway stations, at street stands, and in the push carts of vendors, as well as in private families, a common seaweed food article in all parts of Japan takes the place of a sandwich in America, and is called *sushi*. On a sheet of amanori boiled rice is spread, and on the rice strips of meat or fish are placed; the whole is then made into a roll and cut into transverse slices. From the following analyses furnished by the Imperial Fisheries Bureau it appears that amanori is rich in proteid matter and is a nutritious food:



Preparing laver sheets.

*Composition of Porphyra.*

| Locality. | Weight of 10. sheets. | Water. | Protein. | Fat. | Ash. |
|---|---|---|---|---|---|
| | *Grams.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Suna | 41 | 14.575 | 32.444 | 0.700 | 9.000 |
| Do | 37 | 16.395 | 35.625 | .500 | 9.340 |
| Fukagawa | 32 | 20.415 | 36.263 | 1.210 | 8.830 |
| Shinagawa | 30 | 15.475 | 34.350 | .650 | 10.685 |



The preparation of *Porphyra*. From a Japanese print.

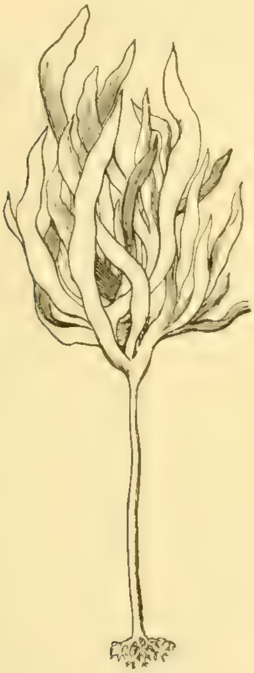
## SEAWEED IODINE.

### GENERAL INFORMATION.

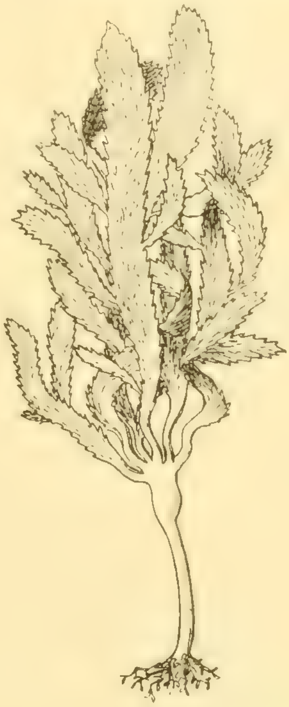
Although the manufacture of iodine from seaweeds is of comparatively recent origin in Japan, that country now supplies a considerable part of this commodity used in the world, supplanting Scotland, which formerly produced most of the iodine extracted from marine plants. Up to ten years ago the business was very profitable, but, owing in part to competition and in part, perhaps, to a scarcity of suitable raw material, it has become less remunerative.

The chief localities for the manufacture of iodine are in Hokkaido and the prefectures of Chiba, Kanagawa, Yamaguchi, and Shizuoka. No general statistics are available, and it is not known how extensive the business now is, but the following extract from the Yokohama Shimpo gives some idea of its importance (1903):

> Although the manufacture of iodine in Japan can not as yet be said to be carried on extensively, yet it is a matter for congratulation that it has been so far advanced as to put a complete stop to the importation of the foreign article, and the manufacturers in all parts of the country are making pretty good profits out of the business. The general tendency is that, with the increase of demand for the chemical, the business would become one of the most important industries in the Empire. In the case of Kanagawa prefecture, Mr. Sudzuki, of Hayama, near Yokohama, started the manufacture of iodine at that place a few years ago with a small capital. The business has now proved so successful that he has enlarged the business to such an extent as to enable him not only to meet the demand at home but also to export some of the product to foreign countries. Probably this is now the largest factory of the kind in Japan. It is said that, as a result of careful investigations, he has now discovered that the residue left after extracting iodine from seaweed can be used as material for making nitrate of soda and chloride of sodium, and that he at present turns out some 12,000 yen worth of the latter article in a year. The difficulty, however, seems to be that it is no easy work to collect such a quantity of seaweed as is required in the manufacture.



"Kajime" (*Ecklonia cava*).



"Arame" (*Ecklonia bicyclis*).

### THE ALGÆ UTILIZED.

Iodine exists in many species of marine algæ, and in Japan is obtained from about ten species, representing three or four genera. In Hokkaido only "kombu" (kelp) of various kinds is used, but in other sections the seaweeds in greatest favor are "kajime" (*Ecklonia cava*), "arame" (*Ecklonia bicyclis*), and "ginbaso" (*Sargassum*). The following table, based on the analyses of the Imperial Fisheries Bureau, shows the proportion of iodine in different algæ. It will be seen that the percentage of iodine in *Sargassum* is very small, while kelp (*Laminaria*) contains by far the largest percentage in a given quantity of ash and *Ecklonia* the largest percentage in the fresh weed.

*Analyses of seaweeds from which iodine is extracted.*

| Japanese name. | Scientific name. | Locality. | Iodine in raw weed. | Ash in 100 parts weed. | Iodine in 100 parts ash. |
|---|---|---|---|---|---|
| | | | *Per cent.* | *Per cent.* | *Per cent.* |
| Kajime | Ecklonia cava | Chiba Prefecture | 0.232 | 54.828 | 0.424 |
| Do | do | Yamaguchi Prefecture | .251 | 47.223 | .531 |
| Arame | Ecklonia bicyclis | do | .271 | 50.904 | .531 |
| Ginbaso | Sargassum sp | do | .054 | 52.042 | .104 |
| Do | do | Chiba Prefecture | .029 | 51.941 | .057 |
| Kombu | Laminaria angustata | Hokkaido | .180 | 18.686 | .990 |
| Do | Laminaria longissima | do | .173 | 27.290 | .634 |
| Do | Laminaria japonica | do | .106 | 17.156 | .619 |
| Do | Laminaria ochotensis | do | .188 | 20.308 | .922 |

The iodine salts are not uniformly distributed in the different parts of the plants, and moreover vary in quantity from month to month. These points are brought out in detail in the following interesting series of analyses of "kajime" (*Ecklonia cava*) from the Chiba coast, made by the Imperial Fisheries Bureau:

*Analysis of Ecklonia cava.*

| | March. | April. | May. | June. | July. | August. | September. |
|---|---|---|---|---|---|---|---|
| Young stalk: | | | | | | | |
| Iodine in 100 parts of material | 0.061 | 0.067 | 0.093 | | | | 0.177 |
| Ash in 100 parts of material | 45.42 | 46.78 | 44.28 | | | | 45.63 |
| Iodine in 100 parts of ash | .134 | .144 | .209 | | | | .388 |
| Young leaf: | | | | | | | |
| Iodine in 100 parts of material | .063 | .060 | .084 | | | | .143 |
| Ash in 100 parts of material | 47.27 | 45.75 | 43.17 | | | | 48.90 |
| Iodine in 100 parts of ash | .134 | .130 | .195 | | | | .290 |
| Old stalk: | | | | | | | |
| Iodine in 100 parts of material | .118 | .118 | .147 | 0.255 | 0.216 | 0.142 | .267 |
| Ash in 100 parts of material | 46.77 | 44.64 | 48.76 | 49.95 | 42.95 | 48.30 | 45.07 |
| Iodine in 100 parts of ash | .252 | .263 | .302 | .507 | .507 | .346 | .592 |
| Old leaf: | | | | | | | |
| Iodine in 100 parts of material | .101 | .114 | .076 | .294 | .294 | .142 | .592 |
| Ash in 100 parts of material | 48.42 | 43.64 | 45.28 | 50.16 | 41.00 | 54.12 | 43.89 |
| Iodine in 100 parts of ash | .209 | .261 | .167 | .586 | .717 | .262 | .528 |

The seaweeds are gathered chiefly in summer, some from the shores where they have been washed, some from submerged rocks and small stones by means of a knife attached at right angles to a bamboo pole. It is reported that the supply of algæ most valuable for iodine manufacture is diminishing.

TREATMENT OF THE ALGÆ.

The weeds are dried on the shores in the sun, then heaped and burned. The ash is collected and either sold to the manufacturers or treated by the fishermen themselves. Following is an outline of the reducing process:

The ash is washed with fresh water, and the soluble parts are thus extracted. The extract is then evaporated in iron pans over a fire, and a concentrated brine is obtained. Besides iodine, this brine contains potassium chloride, sodium chloride, magnesium chloride, and calcium sulphate, which during further evaporation crystallize out, leaving magnesium and potassium iodides in solution. The extract is finally placed in a glass or porcelain retort with sulphuric acid and potassium permanganate, and boiled, the iodine passing over and depositing in crystals. This product, however, is not strictly pure, and refining is necessary. Refining factories are located in Tokyo and Osaka.

The fishermen send their ash to the manufacturers in straw bags like those used for rice. As the ash is sold by weight, the fishermen are said to be not over careful to exclude sand and other foreign matter.

The output of crude iodine in Hokkaido in 1901 was 12,405 pounds, valued at $15,866.

### OTHER JAPANESE ALGÆ AND THEIR USES.

The foregoing are the principal seaweeds and their applications in Japan, but there are many other species utilized in various ways. Many algæ are not objects of trade, but are employed for home purposes, and the annual consumption of these is very large. Some are used for making jellies, some as vegetables, some as salads, some as condiments, and some for decorative purposes. Large quantities are also used for fertilizers. In few countries is agriculture more thoroughly intensive than in Japan, and the need and demand for fertilizers are most pronounced. Among the minor species which are especially sought and are most used, the following may be mentioned. For the information concerning them the writer is chiefly indebted to Dr. K. Oku, chemist of the Imperial Fisheries Bureau, and to the paper by Yendo on "Uses of Marine Algæ in Japan."

"Arame" (*Ecklonia bicyclis*).—This alga, which is employed in the manufacture of iodine, is also used as food and fertilizer. It grows on reefs on the coast of various provinces, and is gathered from March to July. Its greatest length is about 2 feet. The chemical composition of the plant, as determined by Prof. Dr. Edward Kinch, formerly of the Agricultural College of Tokyo University, is water, 13.17 per cent; protein, 8.99 per cent; carbohydrates, 45.09 per cent; fiber, 7.40 per cent; and ash, 24.74 per cent. "Arame" is chiefly eaten as an ingredient of soups, as a salad, or mixed with soy-bean sauce. In localities where it grows abundantly it is sometimes spread on the land. The dried stem is very hard and may be used as handles for knives or other such implements. "Kajima" (*Ecklonia cava*) is not used for food, but is extensively employed for the decoration of houses on festive occasions.

"Hijiki" (*Cystophyllum fusiforme*) grows on rocks that are exposed at low tide, and is gathered therefrom between January and May. In January and February, when it is very small and tender, its quality is better than in other months; the largest size attained is 6 to 8 inches. This species is sun dried and is ready for use after boiling in fresh water or cooking with soy-bean sauce. Following is the chemical composition, according to Doctor Kinch: Water 16.40 per cent, protein 8.42, carbohydrates 41.92, fiber 17.06, and ash 16.20.

"Wakame" (*Undaria pinnatifida*) is dried and sold in bales, and is a common food article in parts of Japan. Before being used it is washed with fresh water, and then eaten as a salad, cooked with soy-bean sauce or put in soups. Yendo states that the peasants in northern Japan cut off the ripe sporophyls (fronds bearing sacs) and press them into a slimy liquid which is eaten after mixing with boiled rice. In some places "wakame" is treated much like "ama-nori" before being eaten; that is, it is put in a basket or tray with a wire mesh bottom and parched over a slow charcoal fire. Another method of preparation, peculiar to the province of Shima, is to cut the dried weed into 1-inch lengths and put them in cans or other vessels with sugar. The thick root of "wakame," called "mehibi," is often dried, shaved, or cut into thin slices, and eaten with sauce (miso). "Wakame" usually grows on rocks in currents or where the water is not sluggish, at depths of 20 to 40 feet. It is gathered in many provinces during winter by means of long poles terminating in a radiating cluster of long teeth or prongs, the weeds being torn from their attachment by a twisting motion.

"Suizenji-nori" (*Phylloderma sacrum*).—This species derives its name from the place where it is prepared. Suizenji is a park in Higo Province near Kumamoto, belonging to an old lord of the famous Hosokawa family. In this park is a large fresh-water pond, and at the lower end of this pond is a small lake from which "suizenji-nori" is gathered, and on the shore of which it is dried.

This product is ordinarily eaten with raw fish (*sashimi*); the dry weed is soaked in fresh water, and after it has swelled boiling water is sprinkled over it and then soy-bean sauce is added. In the time of the feudal system this preparation was regularly presented to the local daimyo.

"Awo-nori" (*Enteromorpha compressa*, *E. intestinalis*, and *E. linza*) grows in river mouths where fresh and salt water mix, and is cropped from November to April, being preserved by drying in the sun in sheets or bunches. Dr. O. Kellner gives the following analysis of dried *E. compressa:* Water 13.60 per cent, protein 12.41, fat and carbohydrates 52.99, fiber 10.58, and ash 10.42. "Awo-nori" is eaten after being gently heated over a charcoal fire and crushed or powdered; it has a very good flavor, and is used chiefly as a condiment. The first two species are abundant on the United States coasts.

"Aosa" (*Ulva lactuca*), the well-known sea lettuce of the United States, is much used in Japan in the same way parsley and lettuce are often employed by Americans—that is, as a garnishment for meats, fish, and salads.

"Miru" (*Codium tomentosum*, *C. mucronatum*, *C. lindenbergii*).—These species grow on rocks and stones along the shores of various provinces, and are cropped in April or May. After drying they are preserved in ash or salt. They are prepared for food by boiling or baking in water, and are put in soups; or, after washing, by mixing with soy-bean sauce and vinegar.

"Haba-nori" (*Phyllitis fascia*).—This plant is prepared for use after the manner of "awa-nori" (*Porphyra*), principally by peasants of the provinces of Awa and Sagami. The young fronds are dried in the sun in sheet form and subsequently parched, powdered, and mixed with soy-bean sauce.

"Matsuma" (*Chordaria abietina*).—This species, which resembles a spray of fir, abounds in northern Japan, and is consumed in large quantities by the peasantry.

It is preserved by packing in salt, and is cooked with soy-bean sauce. Yendo refers to an interesting use to which it is put, namely, the preservation of mushrooms. The mushrooms are washed in fresh water and then packed in tight barrels in layers alternating with layers of salted seaweed.

"Mozuku" (*Mesogloia decipiens*) reaches a length of about 1 foot, and is gathered in April or May while young. It is preserved by salting, and is eaten after washing out the salt and immersing in soy-bean sauce or vinegar.

"Hondawara" (*Sargassum enerve*) grows on reefs on the seacoasts, and is used as fertilizer after being piled on the shore and allowed to decompose. When the plant is young it is eaten in soup or with soy-bean sauce. It has a bright green color when dried, and has been employed from a very remote time, intertwined with *Laminaria*, in New Year's Day celebrations. Numerous other species of *Sargassum*, collectively called *mo* or *moku*, are employed as fertilizer in middle and southern Japan.

"Somen-nori" (*Nemalion vermiculare*) grows on rocks on various parts of the coast, being particularly abundant in San-in, Hoku-roku, and the northeastern districts, and rarely found in the Sea of Tokaido. Its length is 5 to 12 inches. It is generally preserved by simply drying, or by mixing with ash or salt, and is eaten in soup or after mixing with vinegar and soy-bean sauce. In some places "umi-zomen" (*N. lubricum*) is dried, bleached, and eaten like the foregoing species.

"Tosaka-nori," meaning crest-like seaweed (*Kallimenia dentata*), grows on reefs of Kozu Island and also in the provinces of Ise, Shima, and Higo, at depths of 8 feet to several fathoms, and is collected on the shores in August and September after a strong wind. It is preserved by drying, and is eaten as a condiment or mixed with soy-bean sauce.

"Tsuno-mata," "hosokeno-mimi" (*Chondrus crispus*, *C. ocellatus*, etc.).—The well-known "Irish moss" occurs on the coast of Japan and, with related species, is employed in a variety of ways, after first being dried in the sun. When boiled to form a jelly, these plants are used as food, as starch for stiffening linens, as a washing medium, and as a substitute for agar-agar.

"Ogo-nori" (*Gracilaria confervoides*).—According to Yendo, this is a favorite seaweed for garnishment in Tokyo, after being treated with lime water or dipped in hot water to change the color from pink to green.

Other Japanese algæ which are dried and eaten or utilized in various other ways are: "Cata-nori" (*Gigartina teedii*), "comen-nori" (*Grateloupia affinis*), "mukade-nori" (*Grateloupia filicina*), "makuri" (*Digenea simplex*), "ego" (*Campylaephora hypneoides*), "okitsu-nori" (*Gymnogondrus flabelliformis*), and "tosaka" (*Sarcodia* species).

# THE UTILIZATION OF SEAWEEDS IN THE UNITED STATES.

By HUGH M. SMITH,
*Deputy U. S. Fish Commissioner.*

VIEWS OF THE IRISH MOSS INDUSTRY OF MASSACHUSETTS.

# THE UTILIZATION OF SEAWEEDS IN THE UNITED STATES.

By HUGH M. SMITH,
*Deputy U. S. Fish Commissioner.*

With seaweed resources certainly not inferior to those of Japan or any other country, and probably much superior, the United States may be said practically to ignore these valuable products except at a few points on its extensive coast. Statistics recently gathered give the paltry sum of $35,000 as the value of the marine algæ prepared in the United States in one year. The business is practically restricted to Massachusetts, and is addressed to a single species, the "Irish moss" (*Chondrus crispus*). Considerable quantities of seaweeds are used as fertilizer on farms adjacent to the coast, but this is not a commercial enterprise. In Monterey and Santa Barbara counties, Cal., the Chinese fishermen dry certain algæ for food, medicine, and fertilizer; in 1899 the quantity prepared was 35,824 pounds, valued at $896.

There is undoubtedly a good opportunity to develop the seaweed industry of every section of the United States coasts, and to establish a profitable trade in the various species and preparations of marine algæ along the new lines indicated in the foregoing paper on the Japanese seaweed industry, as well as by increasing the output of the species already sparingly utilized. To this end the following information and suggestions are offered in regard to some of the useful algæ of the United States.

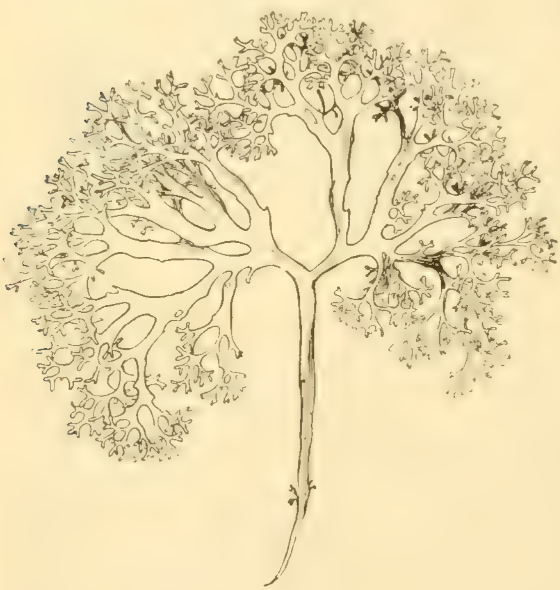
### IRISH MOSS, OR CARRAGEEN (*Chondrus crispus*).

This alga is found from North Carolina to Maine, being especially abundant north of Cape Cod, growing on rocks just below low-water mark. The fronds are 3 to 6 inches long and usually purple, but when growing exposed to a bright light are yellowish-green. There are various other algæ considered to be quite as useful as *Chondrus crispus* for the purposes for which the latter is gathered. Among them are several species of *Chondrus* found on the California coast; various species of *Gracilaria*, found from Key West to Cape Cod and also on the Pacific coast; *Eucheuma isiforme*, found in the Key West region; and *Gigartina mamillosa* and numerous other species of *Gigartina*, which closely resemble *Chondrus* and abound on our east and west coasts.

The plant has from time to time been gathered on various parts of the New England coast, but at present is utilized at only a few localities in New Hampshire and Massachusetts, the principal place being Scituate, where it would seem the business has always been more important than at any other place on our coast. It is recorded (Wilcox, 1887) that prior to 1835 the small quantity of Irish moss used in this country was imported from Europe and sold here at one to two dollars a pound, and that in the year named Dr. J. V. C. Smith, at one time mayor of Boston, made it generally known that the "moss" which abounded on the Massachusetts shores was the same as that which was imported at such a high price. From that time to the present Irish moss has been prepared at Scituate, and in 1879 was the leading marine production. By 1853 the price, which in 1835 was $1 a pound, had dropped to 25 cents, and by 1880 to 3 or 3½ cents. About 1880 the average annual yield was 5,000 barrels of dried weed, averaging 90 pounds to the barrel.

The methods of conducting the business have changed but little in many years, and the simple apparatus required remains the same as in the early days of the industry. Mr. T. M. Cogswell, of the Bureau of Fisheries, has furnished the data on which the following account is based.

A small part of the crop is gathered by hand, but most of it is torn from the rocks by means of rakes used from boats. The rakes are made especially for the purpose, and have a 15-foot handle and a head 12 to 15 inches wide, with 24 to 28 teeth 6 inches long and an eighth of an inch apart.


Irish moss (*Chondrus crispus*).

The gathering season extends from May to September. If the rocks are not scraped too clean in the early part of the season, it is said to be possible to get two crops in some of the warm, sheltered coves, where the alga grows much faster than in the more exposed places.

The output in recent years has varied considerably, owing chiefly to the inclination or disinclination to engage in the business. Some years a large number of people seem moved by a desire to gather the weed, while other seasons only a few go into the business. Occasionally heavy storms do damage by tearing the plant from the rocks and scattering it along miles of beach. There is said to be a scarcity at times, owing, it is supposed, to too active gathering the previous season, the rocks being almost completely denuded.

In the preparation and curing of Irish moss fair weather and much sunshine are prime requisites. When first brought ashore, the plants are washed in salt water and then spread upon the sandy beach to dry and bleach. After twenty-four hours in good weather they are raked up and again washed and again spread on the beach to dry. Three washings are usually sufficient for complete cleansing, curing, and bleaching, but as many as seven are sometimes given. After the final washing the plants are left in the sun, the entire process requiring about two weeks of good weather and warm sunshine. The plants gradually fade, and by the time the curing is finished they are white or straw colored. Two more weeks are then required to sort and prepare the product for shipping.

Great care has to be exercised in the curing to prevent the rain from spoiling the crop, and when a storm is impending the moss is hastily raked in piles and covered with canvas. Should it chance to get wet in the last week of its curing, it is practically ruined.

The moss is sent to market in barrels holding 100 pounds, and the first of the crop is usually shipped in August. The product has a wide distribution in the United States and Canada, a part of it going to druggists and grocers, but much the larger part to brewers and firms handling brewers' supplies. The wholesale price was 4 to 4½ cents per pound in 1902, and 5 to 5½ cents in 1903.

From information regarding this business recently gathered by the Bureau of Fisheries, it is seen that 136 men were employed in gathering this plant in 1902; the boats, rakes, and shore property used were valued at over $12,000; and the quantity of dried algæ sold was 740,000 pounds, with a market value of $33,300. In 1898 the output was 770,000 pounds, valued at $24,825.

*Statistics of the Irish moss industry of New England for 1902.*

| Locality. | Men. | Boats. |  | Rakes. |  | Shore property. | Product. |  |
|---|---|---|---|---|---|---|---|---|
|  |  | Number. | Value. | Number. | Value. |  | Pounds. | Value. |
| Massachusetts: |  |  |  |  |  |  |  |  |
| Scituate | 100 | 15 | $1,873 | 75 | $375 | $5,000 | 500,000 | $22,500 |
| North Scituate | 5 | 5 | 200 | 5 | 25 | 200 | 30,000 | 1,350 |
| Cohasset | 10 | 12 | 480 | 10 | 50 | 600 | 60,000 | 2,700 |
| Plymouth Harbor and White Horse Beach | 15 | 14 | 730 | 15 | 75 | 700 | 100,000 | 4,500 |
| New Hampshire: |  |  |  |  |  |  |  |  |
| Rye Harbor | 6 | 8 | 240 | 6 | 30 | 1,500 | 50,000 | 2,250 |
| Total | 136 | 54 | 3,523 | 111 | 555 | 8,000 | 740,000 | 33,300 |

Irish moss of excellent quality is now placed on the market in 1-pound and half-pound boxes, selling at retail for 45 cents and 25 cents, respectively; it is intended chiefly for making blanc mange, and is used as follows: Soak half a cup of dry moss in cold water for five minutes, tie in a cheese-cloth bag, place in a double boiler with a quart of milk and cook for half an hour; add half a teaspoonful of salt or less, according to taste, strain, flavor with a teaspoonful of lemon or vanilla extract if desired, and pour into a mold or small cups, which have been wet with cold water; after hardening, eat with sugar and cream. To make a demulcent, for coughs, place moss in cold water and heat gently until the liquid is of a sirupy consistency, then strain and add sugar and lemon juice to suit taste.

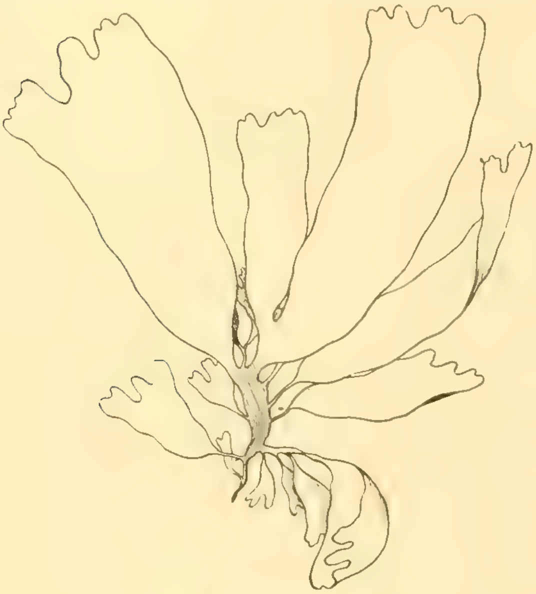
Other uses to which it has been put are the making of jellies and puddings, the clarifying of beers and the sizing of fabrics.

## VEGETABLE ISINGLASS FROM GELIDIUM CORNEUM.

The identical species of alga from which the Japanese prepare their "kanten," or vegetable isinglass, grows in abundance on our Pacific coast, and is also found at various places between Florida and Maine. Other species (*G. coulteri*, *G. cartilagineum*) exist on the coast of California and about the Philippine Islands. The high price of this product and the large consumption of it and fish isinglass in the United States warrant the belief that a profitable business could be established.

Isinglass made from *Gelidium* is one form of agar-agar, now so extensively used in making culture media in bacteriological work. Other sources are the Australian and Asiatic plants, *Eucheuma spinosum*, *Gracilaria lichenoides*, *G. tenax*, and other related species, which yield the products known in commerce as agar-agar, agar-agar gum, agal-agal, Bengal isinglass, Bengal isinglass gum, Ceylon moss, Ceylon agar-agar, Chinese moss, etc.

Vegetable isinglass is composed largely of gelose or pararabin, a substance remarkable for its gelatinizing properties, which exceed those of any other known product. It is insoluble in cold water, alcohol, dilute acids, and alkalies; its melting point is 90° F; it has eight times the gelatinizing power of ordinary gelatine and isinglass; and 1 part to 500 parts of boiling water forms a jelly on cooling. Gelose jelly keeps well, but owing to its high melting point is not so well adapted for food preparations as some other jellies.



Dulse (*Rhodymenia palmata*).

### DULSE (*Rhodymenia palmata*).

The dulse is found along the shores of all the States from North Carolina to Maine, and is very abundant in New England. It is rough-dried in the sun, and eaten dry as a relish. It is met with in stores in the coastwise towns of the Eastern States, but is usually brought from the Canadian provinces, and has not figured in recent statistical canvasses of the New England fisheries. Other species of this genus grow on the west coast of the United States. Several other algæ known as dulse in Europe, and used in the same way as *Rhodymenia*, are represented by various species on the Pacific coast of America. In Ireland, dulse is eaten with butter and fish, and is also boiled in milk with rye flour (Simmonds, 1883). Some gentlemen in the Scotch Highlands known to Stanford (1884) are quoted as holding that "a dish of dulse boiled in milk is the best of all vegetables." Swan (1893) states that dulse is common on the northwest coast and is an article of diet among the Haida Indians of Queen Charlotte Island and other tribes, although not in general use. Like the green and purple laver used by the same Indians, it is dried and compressed into blocks, and as needed is sliced with a sharp knife, soaked in fresh water, and boiled. Swan partook of an Indian meal of dulse boiled with halibut and found it very palatable.

### LAVER (*Porphyra laciniata*).

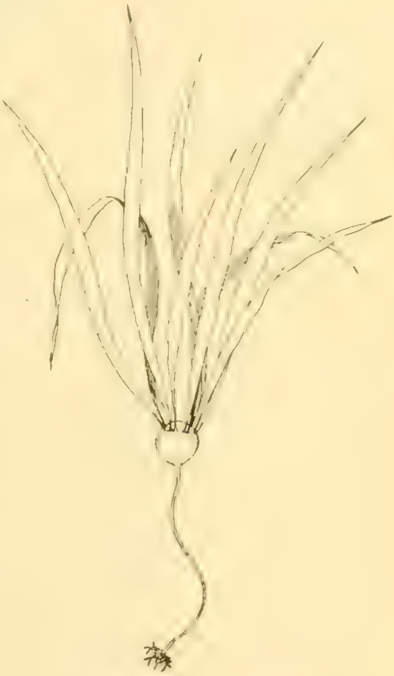
This alga is found in abundance along the entire coast, but is not collected except sparingly by Chinese, who obtain most of their supply from Asia. It was recorded in 1876 by Farlow that laver was imported from China by the Chinese living in this country, even by those as far east as Massachusetts, although the plant is common on the Massachusetts shores. The considerable demand for *Porphyra* among oriental people in the United States should be supplied from local sources, the algæ being prepared after the Japanese method or by simple washing and drying.

In Ireland, where it is called "sloke," laver is boiled and served with butter, pepper, and vinegar as a dressing for cold meat.

### GIANT KELP; GREAT BLADDER-WEED (*Nereocystis lütkeana*).

This most remarkable plant, which attains an enormous length, grows on the Pacific coast from Monterey Bay northward. Swan (1893) writes as follows regarding it in the Puget Sound region:

> The *Nereocystis* of the northwest coast is said, when fully grown, to have a stem measuring 300 feet in length, which bears at its summit an air bulb, from which a tuft of upward of 50 long, streamer-like leaves extend, each of which is from 30 to 40 feet in length. The stem, which anchors this floating mass, though no thicker than a common window cord, is of great strength and flexibility, and has for ages been used by the natives as fishing lines, being first cut of the required length, which is where the stem begins to expand into the hollow tube, and varies from 10 to 15 fathoms, then soaked in fresh water in a running brook until it is nearly bleached, then stretched, rubbed to the required size, and dried in the smoke in the lodge. When dried it is very brittle, but when wet it is exceedingly strong, and equal to the best flax or cotton fishing lines of the white fishermen. These pieces, varying from 10 to 15 fathoms each, are knotted together to the required length of 80 fathoms, required in the deep-water fishing around the entrance to Fuca Strait, or 200 fathoms at Queen Charlotte Islands, British Columbia, where the natives take the black cod at that profound depth.
>
> Until within a few years the coast Indians used the upper or hollow portion of these great kelp stems as receptacles for holding dog-fish oil, which, together with the paunches of seals and sea-lions and whale gut, properly prepared, were the utensils found in every house for holding the family supplies of whale, seal, or salmon oil which are used as articles of food, or for dog-fish oil, which is used for trading purposes only. Now, however, the Indians are using coal-oil cans, barrels, and other utensils easily procured from the white traders, and the use of kelp for holding oil is nearly abandoned.
>
> Among my collections for the National Museum in 1885 I received a number of specimens of



Giant kelp (*Nereocystis lütkeana*).

this kelp which had been used for dog-fish oil. I split one open and found that the oil had hardened the inside of the kelp tube to the consistency of leather. This specimen I washed with soap and water, then wiped it to remove the moisture, and then rubbed and manipulated it after the manner used by natives in dressing deer skins, and when perfectly dry by this process of continual rubbing, it was soft and flexible, presenting an appearance of wash leather, but if allowed to dry without manipulation it would be hard and brittle. A party of coast Indians were camped on the beach at Port Townsend, and, at my request, they showed me their method of preparing kelp for holding oil. The great stems of the *Nereocystis* are covered with a thin coating of silex, which is carefully pealed off as one might peel the skin from an apple; only the hollow or upper part of the stem is used. When the skin is removed the tube is placed above the fire and smoke in the lodge, and, as it dries, the salt it contains exudes on the surface; this is carefully removed by rubbing, which also serves to soften the kelp and render it pliable. It is then again placed over the fire, and the process continued until the salt is removed; then the tube is blown up like a bladder and allowed to dry until it will retain its shape, and it is then filled with dog-fish oil and is ready for market.

The rude and simple experiments I made with this giant kelp convinced me that it is capable of being converted into articles of commercial value, but as I had not the means of conducting experiments, or of procuring the machinery requisite to the manufacture of the kelp products on a scale of commercial importance, I have allowed the matter to rest until some one of enterprise and capital may be found ready to continue these investigations.

* * * * * * *

During a residence of many years in the vicinity of Cape Flattery, at the entrance of Fuca Strait, I have had ample time and opportunity to observe the great masses of the giant kelp and other marine plants which are torn up by the roots every fall by the storms and piled by the waves along the beach at Neah Bay. I have frequently noticed, when a mass of this kelp has been thrown into a pool of fresh water, that in a few days it is covered with this slippery substance, which Stanford (1884) has named algin, and I think that the *Nereocystis* is rich with this valuable ingredient. The supply of the raw material is practically unlimited, and if attention shall be directed to the valuable uses to which this plant and other algæ may be put, I feel confident that a new and important industry will be developed.

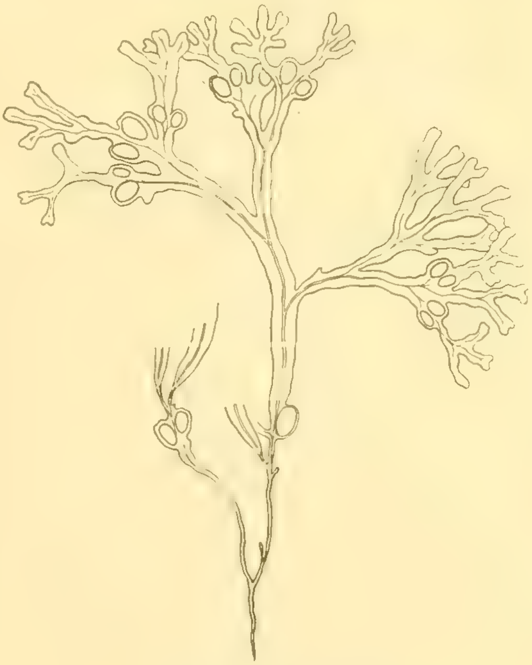
### FOOD PREPARATIONS FROM THE KELPS.

Numerous species of *Laminaria* exist on the northern parts of both coasts of the United States. The only use to which the plants are now put is for fertilizer. There is no question but that some of the Japanese "kombu" preparations would meet with ready sale, not only among Chinese and Japanese in the United States and its island possessions, but also among natives. The forms of "kombu" which are likely to prove most acceptable to the American palate are the powders, films, and dried sticks. It occurred to the writer that the crisp sticks might be broken into small pieces and serve as a breakfast dish, like oatmeal or other cereal. An Osaka manufacturer accordingly prepared some in the form of small rectangular flakes, which, when moistened with milk or hot water, formed a very wholesome and agreeable dish.

### KELP AND OTHER SEAWEEDS CONTAINING IODINE.

Algæ representing species identical with or similar to those used in Scotland, France, and Japan in the manufacture of iodine abound on the northern coasts of the United States, but are never used for this purpose. In view of the large consumption of iodine in the United States and the facility with which it may be prepared, in crude form, at many places on the New England and North Pacific coasts, it is quite remarkable that no one has undertaken the manufacture of this product. Supplementary to the outline of the Japanese method of preparing iodine, it is therefore deemed advisable to give some account of the iodine industry in Scotland.

Nearly all marine algæ contain iodine, but a few have such a comparatively large quantity that they are utilized almost exclusively. In the early days of iodine and soda manufacturing on the Scotch coasts, only "rockweeds" or "wrack," technically known as cut-weed kelp, were used; they represented three species namely, *Fucus vesiculosus*, *F. serratus*, and *Ascophyllum nodosum*. Stanford (1884) gives an interesting historical account of this industry:



Rock weed (*Fucus vesiculosus*).

> This crude substance (kelp), which for many years made the Highland estates so valuable, was at first made as the principal source of carbonate of soda. At the beginning of the century it realized £20 to £22 per ton, and the Hebrides alone produced 20,000 tons per annum. The importation of barilla then began, and for the twenty-two years ending 1822, the average price was £10 10s. The duty was then taken off barilla, and the price of kelp fell to £8 10s.; and in 1823, on the removal of the salt duty, it fell to £3, and in 1831 to £2. It was used up to 1845 in the soap and glass factories of Glasgow, for the soda. Large chemical works were then existing in the island of Barra for the manufacture of soap from kelp, and a very large sum of money was lost there. In the meantime, soda was being largely made by the Le Blanc process, and superseded kelp, which was always a most expensive source, yielding only about 4 per cent, often less than 1 per cent. It must have cost the soap-makers what would be equal to £100 per ton for soda ash, the present price of which is £6.
>
> The manufacture of iodine and potash salts then began to assume some importance, but the kelp required was not the same, that which contained the most soda containing the least iodine and potash. Chloride of potassium, the principal salt, was at one time worth £25 per ton. The discovery of the Stassfurt mineral speedily reduced this price to about a third, and the further discovery of bromine in this mineral also reduced the price of that element from 38s. per pound to 1s. 3d., its present price. The amount of bromine in kelp is small, about a tenth of the iodine, and not now worth extracting. Large quantities are now produced in Germany and America. More recently, the manufacture of iodine from the caliche in Peru has attained large proportions, and has so far reduced the price of that article as to make its manufacture from kelp unremunerative.
>
> * * * The plants were cut at low tide, floated ashore, dried and burnt. * * * This kelp, burnt into a dense fused slag, contained the most carbonate of soda, and was that variety which employed so many poor crofters and cotters, and enriched so many Highland lairds. It is now worthless, and the *Fuci*, which hang from the rocks at low water in luxurious festoons, are now entirely unutilized.

From the following table given by Stanford, showing the quantity of iodine in various seaweeds, the preponderating value of *Laminaria* for iodine manufacturing will be apparent:

*Iodine in sun-dried seaweeds.*

| Species. | Per cent. | Pounds per ton. | Species. | Per cent. | Pounds per ton. |
|---|---|---|---|---|---|
| Laminaria digitata, "tangle;" stem | 0.4535 | 10.158 | Fucus serratus, "black wrack" | 0.0856 | 1.807 |
| frond | .2946 | 6.599 | vesiculosus, "bladder wrack" | .0297 | .665 |
| stenophylla: stem | .4028 | 9.021 | Halidrys siliquosa, "sea oak" | .2131 | 4.773 |
| frond | .4777 | 10.702 | Hymanthalia lorea, "sea laces" | .0892 | 1.998 |
| saccharina, "sugar wrack" | .2794 | 6.258 | Rhodymenia palmata, "dulse" | .7120 | 1.594 |
| bulbosa | .1966 | 4.403 | Chordaria flagelliformis | .2810 | 6.294 |
| Ascophyllum nodosum, "knobbed wrack" | .0572 | 1.281 | Chorda filum, "sea twine" | .1200 | 2.688 |
| | | | Chondrus crispus, "Irish moss" | Trace. | ..... |
| | | | Gelidium corneum | Nil | ...... |

Three methods of extracting iodine have been followed in Scotland, known as the kelp process, the char process, and the wet process. The following accounts of them are abridged from Stanford's report (l. c.), and from Stanford's article in Thorpe (1899):

*Kelp process.*—This, the primitive method, is similar to that pursued for the extraction of soda from rockweeds. It is unsatisfactory and wasteful, owing to the fact that a large part of the iodine is lost by evaporation and a large part of the remaining substances are not utilized. One hundred tons of wet seaweed usually make 5 tons of dried kelp, and, as only half of this is soluble, 2½ tons are the actual product of the labor of cutting, carrying, drying, and burning 100 tons of raw weed. The fused mass of carbon and ash resulting from the burning of the dried weeds is lixiviated with water, and the solution is evaporated to remove the chlorides, sulphates, and carbonates; the concentrated mother liquid is then treated with sulphuric acid, the resulting sulphur and sulphates are removed, and the remaining acid liquor is treated in a lead-lined retort with manganese dioxide, which, with the free sulphuric acid, liberates iodine; the iodine passes off in vapor and is condensed in a series of earthenware receivers adapted to the retorts. The chemical reaction in this case is as follows:

$$2KI+MnO_2+2H_2SO_4=K_2SO_4+MnSO_4+2H_2O+2I.$$

*Char process.*—This has for its object the prevention of loss of valuable material by volatilization and decomposition, and consists in heating dry seaweed in iron retorts or brick ovens. The tangle swells in the retorts and is converted into a very porous charcoal, from which the salts are readily washed. This charcoal is reported to be an efficient decolorizer and deodorizer. The superiority of the char process over the kelp process will be seen from the following comparison of the results of treating four tons by each process:

| Item. | Kelp process. | Char process. | Item. | Kelp process | Char process. |
|---|---|---|---|---|---|
| Crude product ........pounds.. | 1,500 | 3,000 | Loss of salts ........pounds.. | 220 | ...... |
| Per cent of dried weed | 18.7 | 37.5 | Loss of iodine ........do.... | 15.98 | ...... |
| Salts recovered ........pounds.. | 657 | 877 | Loss of salts per ton of tangle..do.... | 54 | .......... |
| Iodine produced ........do.... | 13.27 | 29.25 | Loss of iodine per ton of tangle..do.... | 3.99 | ...... |

*Wet process.*—Air-dried tangle is boiled with a solution of sodium carbonate, and the mass is filtered. The precipitate is composed largely of cellulose, while the filtrate contains, besides the salts, a peculiar gummy substance, algin. When the filtrate is treated with sulphuric acid, algin is precipitated. The solution, after the removal of algin, is neutralized with calcium carbonate, evaporated, the easily crystallized salts are removed, and the mother liquor is treated for iodine in the usual manner.

This process is the most economical, in that it increases the yield of salts and iodine and reduces the cost by the production of algin and cellulose. The comparative value of the three processes may be readily appreciated from the following table, the figures being on a basis of 100 tons of dry tangle:

| Items. | Kelp process. | Char process. | Wet process. |
|---|---|---|---|
| Dry weed utilized (per cent) | 18 | 36 | 70 |
| Crude product (tons) | 18 | 36 | [a]33 |
| Salts extracted (tons) | 9 | 15 | 20 |
| Iodine extracted (pounds) | [illegible] | [illegible] | [illegible] |
| Residuals (tons): | | | |
| Kelp waste (valueless) | 18 | ... | |
| Charcoal | | 36 | |
| Tar, ammonia | | [illegible] | |
| Algin | | | 20 |
| Cellulose | | | 1 |
| Dextrin, etc. | | | [illegible] |

[a] Water extract.

Writing of the Scotch iodine industry, Stanford (l. c.) noted that the "drift kelp", the only kind now used in making iodine, consists of two species of *Laminaria*, which are always submerged and are torn up by the violent gales so common on the west coast. In Ireland the plants are sometimes cut under water with long-handled hooks. These plants are much damaged by rain or fresh water and are often, after drying, almost valueless, but if properly cured they contain ten times as much iodine as the rock weeds.

### OTHER USES OF THE KELPS.

The collateral substances produced during the extraction of iodine by the wet process deserve consideration on account of their prospective value in the arts. These substances are algin, cellulose, dextrin, and mannite, in addition to the various salts elsewhere referred to. The following account of algin and its compounds is adapted from Stanford (1884), by whom this substance was discovered:

> If the long fronds of the *Laminaria* [*digitata*] be observed after exposure to rain, a tumid appearance will be noticed, and sacs of fluid are formed from the endosmosis of the water through the membrane, dissolving a peculiar glutinous principle. If the sacs be cut, a neutral, glairy, colorless fluid escapes. It may often be seen partially evaporated on the frond as a colorless jelly. This substance, which is then insoluble in water, is the remarkable body to which has been given the name of Algin. The natural liquid itself is miscible with water, but coagulated by alcohol and by mineral acids. It contains calcium, magnesium, and sodium, in combination with a new acid, which is called alginic acid. When this natural liquid is evaporated to dryness it becomes insoluble in water, but it is very soluble in alkalies. This new substance is so abundant in the plant that on maceration for twenty-four hours in sodium carbonate in the cold, the plant is completely disintegrated. The mass

thus obtained has great viscosity, and is difficult to deal with on that account. It consists of the cellulose of the plant mixed with sodium alginate. The cells are so small that they pass through many filters, but by cautiously heating it, the mass can be filtered through a rough linen filter bag, the cellulose being left behind, and after the algin is removed, this is easily pressed.

The solution contains dextrin and other extractive matter, and it is then precipitated by hydrochloric or sulphuric acid; the alginic acid precipitates in light gray albuminous flocks, and is easily washed and pressed in an ordinary wooden screw press. It forms a compact cake, resembling new cheese, and has only to be stored in an ordinary cool drying room, where it can be kept any length of time. If desired, by adding a little bleach during the precipitation, it can be obtained perfectly white. The algin can be sent out in this state; it is only necessary to dissolve it in sodium carbonate in the cold for use. If, however, it be sent out as sodium alginate, it must be dissolved to saturation in sodium carbonate, the carbonic acid is disengaged, and sodium alginate is formed. If potassium or ammonium carbonate be used, the alginates of potassium or ammonium are formed, which are similar to the soda-salt. The bicarbonates of these alkalies may also be used; but the caustic alkalies are not such good solvents.

The sodium alginate forms a thick solution at 2 per cent; it can not be made above 5 per cent, and will not pour at that strength. Its viscosity is extraordinary. It was compared with well-boiled wheat starch, and with gum arabic in an ordinary viscometer tube; the strengths employed were as follows; it was found impossible to make the algin run at all over the strength employed:

Gum arabic solution, 25 per cent, took 75 seconds=1 in 3.
Wheat starch solution, 1.5 per cent, took 25 seconds=1 in 8.
Algin solution, 1.25 per cent, took 140 seconds=1 in 112.

So that algin has 14 times the viscosity of starch, and 37 times that of gum arabic.

The solution may be alkaline, or neutral, or acid, according to the degree of saturation; if alkaline, it may be made distinctly acid by the addition of hydrochloric acid, but any excess at once coagulates it; a 2 per cent solution becomes semisolid on this addition.

The evaporation is effected in a similar manner to that of gelatin, in thin layers on trays or slate shelves, in a drying room with a current of air, or on revolving cylinders heated internally by steam; high temperatures must be avoided. The solution keeps well. Thus obtained, the sodium alginate presents the form of thin, almost colorless, sheets, resembling gelatin, but very flexible. It has several remarkable properties which distinguish it from all other known substances.

It is distinguished from albumen, which it most resembles, by not coagulating on heating, and from gelose by not gelatinizing on cooling, by containing nitrogen and by dissolving in weak alkaline solution, and being insoluble in boiling water; from gelatin, by giving no reaction with tannin; from starch, by giving no color with iodine; from dextrin, gum arabic, tragacanth, and pectin, by its insolubility in dilute alcohol and dilute mineral acids.

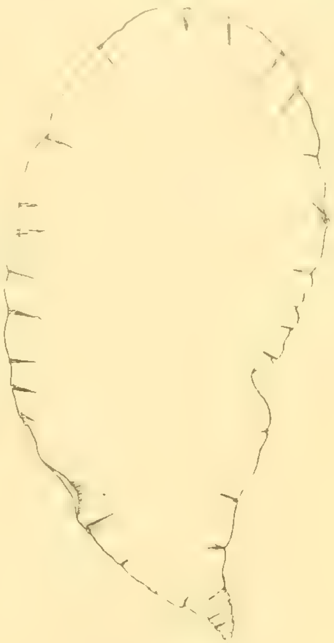
It is remarkable that it precipitates the salts of the alkaline earths, with the exception of magnesium, and also most of the metals, but it gives no precipitate with mercury bichloride nor potassium silicate.

Alginic acid is insoluble in cold water, very slightly in boiling. It is insoluble in alcohol, ether, and glycerin. The proportion of soda ash used is one-tenth of the weight of the weed, and the cake of alginic acid obtained is usually about the same weight as the weed. The quantity of dry alginic acid is given below:

| Algæ. | Water. | Alginic acid. | Cellulose. |
|---|---|---|---|
| Laminaria digitata: | | | |
| Stem | 37.04 | 21.00 | 28.20 |
| Frond | 44.00 | 17.35 | 11.00 |
| Laminaria stenophylla: | | | |
| Stem | 34.50 | 25.70 | 11.27 |
| Laminaria stenophylla: | | | |
| Frond | 40.02 | 24.06 | 15.06 |
| Laminaria bulbosa | 43.28 | 17.95 | 11.15 |
| Fucus vesiculosus | 40.10 | 12.22 | 12.22 |

It is not necessary to extract the salts first with water; it comes to the same thing to act on the seaweed at once with soda ash, and to recover the salts by evaporation of the solution, after the alginic acid has been precipitated. In this case chloride of calcium, or of aluminum, may be employed, the alginate of calcium or aluminum being precipitated. With either salt the alginate is thrown down instead of rising to the surface of the liquid, and the cakes are more compact and easily pressed. In addition to the cheapness with which it can be procured in almost any quantity, as a by-product in alkali works, now all thrown away, the calcium chloride has the advantage of throwing down the sulphates in the salts, and decomposing them into chlorides of potassium and sodium, which are easily separated, and do not require the tedious and expensive processes necessary in the lixiviation of kelp. The same remark applies to aluminum chloride, which can be cheaply obtained by dissolving bauxite in hydrochloric acid. Either salt can be decomposed by hydrochloric acid, and the calcium and aluminum chlorides recovered; or the salts can be decomposed by sodium carbonate. The calcium alginate, when dry, is very like bone, as the dry alginic acid is like horn. The aluminum alginate is soluble in caustic soda, forming a neutral solution, and giving, on evaporation, a substance like algin, but harder and making a stiffer finish; it is also soluble in ammonia, the salt becoming an insoluble varnish on evaporation. The alginates of copper (blue), nickel (green), cobalt (red), chromium (green), and zinc are all soluble in ammonia, and form beautiful colored insoluble films on evaporation. So also do the alginates of platinum, uranium (yellow), and cadmium. The latter is exceedingly soluble in ammonia. The alginate of chromium is also soluble in cold water, and it is deposited on boiling the solution, becoming then insoluble.

With bichrome, algin acts as gelatin, the mixture becoming insoluble under the influence of light. The silver alginate darkens very rapidly under exposure to light, and suggests applications in photography. Algin forms a singular compound with shellac, both being soluble in ammonia; it is a tough sheet, which can be rendered quite insoluble by passing it through an acid bath.



Sea lettuce (*Ulva latissima*).

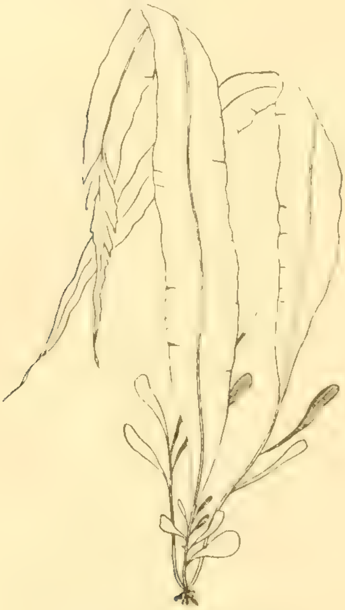
Algin and its salts appear to have a wide range of usefulness. Some of these are indicated by Stanford (l. c.). Thus, as a sizing for fabrics, algin supplies the great desiderata of a soluble gum with marked elastic and flexible properties, and of a soluble substitute for albumen which can easily be rendered insoluble and used as a mordant. As a stiffening and filling agent, algin has an advantage over starch, in that it fills the cloth better, is tougher and more elastic, is transparent when dry, and is not acted on by acids. It imparts to fabrics a thick, elastic, clothy feeling, without the stiffness caused by starch. An additional advantage, possessed by no other gum, is that algin becomes insoluble in the presence of dilute acids; and, furthermore, no other gum has anything like the viscosity of algin, hence it is the most economical for making solutions for sizing. The alginate of aluminum in caustic soda makes a stiff dressing; in the crude unbleached state it is a cheap dressing for dark goods, and in the colorless state for finer fabrics. A glossy, insoluble surface results from the use of ammoniated alginate of aluminum.

Sodium alginate has been used for fixing mordants, and is a substitute for the various salts now used in precipitating mordants previous to the dyeing of cottons and yarns. For resolving and preventing the incrustation of boilers, sodium alginate has been pronounced by experts to be one of the best preparations, precipitating the lime salts in a state in which they can readily be blown off.

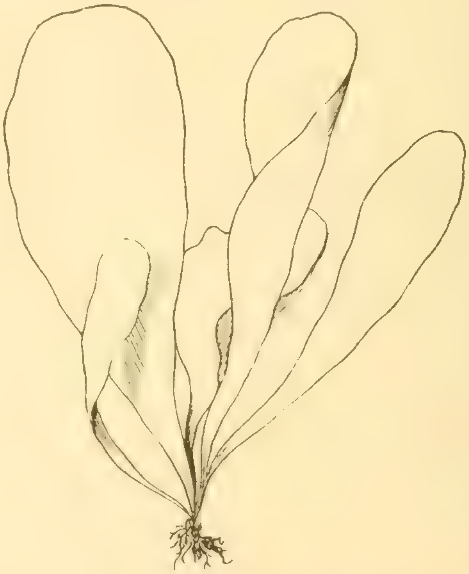
The charcoal formed during the manufacture of iodine by the wet process, when combined with algin, has been largely used for covering boilers, under the name of carbon cement. Three per cent of algin is sufficient to make the charcoal cohere, and a cool, light, and efficient covering is formed.

As an article of food, algin has been suggested for thickening soups and puddings, and as a substitute for gum arabic in making lozenges and jujubes. It contains about the same percentage of nitrogen as Dutch cheese, and has a faint, pleasant flavor best expressed by "marine." In pharmacy it has a place in the emulsifying of oils, as an excipient in pills, and for refining spirits.

The cellulose obtained from the *Laminariæ*, as before described, bleaches easily and under pressure becomes very hard, so that it can be easily turned and polished. A good tough paper can also be made from it.



"Badderlocks" (*Alaria esculenta*).



Dulse (*Schizymenia edulis*).

Farlow (1876) records that the rough-dried stems of *Laminaria saccarhina*, *L. longicruris*, *L. flexicaulis*, and other large species of *Laminaria*, under the name of "artificial staghorn", were used for making handles to knives, paper cutters, and other ornamental purposes; and that at one time an attempt was made to establish a manufactory of buttons out of dried *Laminaria* stems at Marblehead; but the attempt was given up, as the buttons did not bear washing.

## OTHER FOOD ALGÆ.

The number of other algæ susceptible of being prepared as palatable and wholesome foods is very large. Many of the genera utilized for this purpose in Japan exist in our waters and should be given a thorough trial.

The sea lettuce, or green laver (*Ulva latissima*), which is abundant on all our coasts, is eaten in Scotland like purple laver, and is also consumed by Indian tribes of the northwest coast.

The "badderlocks," "murlins," or "henware" (*Alaria esculenta*) common on the shores of New England and California, is eaten in Scotland. *Dilsea edulis*, which occurs on the Oregon coast as well as in Europe and Japan, is a food product in Europe, being eaten like dulse, and known by that name in Great Britain.

## REFERENCES.

Farlow, W. G.

1873. List of the Seaweeds or Marine Algæ of the South Coast of New England. Report U. S. Fish Commission 1872, pp. 281–294.

1876. List of the Principal Useful Seaweeds occurring on the United States Coast. In List of Marine Algæ of the United States. Report U. S. Fish Commission 1874–75, pp. 691–718.

1882. The Marine Algæ of New England. Report U. S. Fish Commission 1879, pp. 1–210, plates i to xv.

Simmonds, P. L.

1883. The Commercial Products of the Sea. Third edition.

Stanford, Edward C. C.

1884. On the Economic Applications of Seaweed. Journal of the Society of Arts, Vol. XXXII, 1883–84, pp. 717–732. (Quoted in part by Swan, "Notes on the Fisheries and Fishery Industries of Puget Sound," Bulletin U. S. Fish Commission 1893.)

1886. Alginic Acid and its Compounds. Journal of the Society of Chemical Industry, 1886, pp. 218 et seq.

Swan, James G.

1893. On the Economic Value of the Giant Kelp and Other Seaweeds of the Northwest Coast of North America. In Notes on the Fisheries and Fishery Industries of Puget Sound. Bulletin U. S. Fish Commission 1893, pp. 371–380.

Thorpe, T. E.

1889. A Dictionary of Applied Chemistry. Article "Iodine."

Wilcox, W. A.

1887. [Irish Moss Industry of Scituate.] Fisheries and Fishery Industries of the United States, Section II, Geographical Review, pp. 219–220.

CONTRIBUTIONS FROM THE BIOLOGICAL LABORATORY OF THE BUREAU OF FISHERIES
AT WOODS HOLE, MASS.

# THE FUNCTION OF THE LATERAL-LINE ORGANS IN FISHES.

By G. H. PARKER,
*Assistant Professor of Zoology, Harvard University.*

CONTRIBUTIONS FROM THE BIOLOGICAL LABORATORY OF THE BUREAU OF FISHERIES AT WOODS HOLE, MASSACHUSETTS.

# THE FUNCTION OF THE LATERAL-LINE ORGANS IN FISHES.

By G. H. PARKER,
*Assistant Professor of Zoology, Harvard University.*

## INTRODUCTION.

The habits of fishes, like those of most other animals, are inseparably connected with their sense organs. Thus in the matter of feeding, Bateson (1890) has pointed out that probably the majority of fishes seek their food by sight. Many such fishes when kept in confinement are known not to feed at night or even in twilight, though they may be ravenous feeders in daylight. Other fishes, including the eels, skates, sturgeons, suckers, flat-fishes, etc., many of which are bottom fishes and often nocturnal in their habits, seem not to depend upon sight in seeking their food. Their powers of sight are often deficient, and food excites them chiefly through its action on their organs of taste, smell, or touch. As Bateson observed, none of these fishes start in quest of food when it is first put into their tanks, but remain undisturbed for an interval, doubtless until the scent has been diffused through the water. Then they begin to swim vaguely about, and appear to seek the food by examining the whole area pervaded by the scent. The search is always made in this tentative way, whether the food is hidden or within sight, and it is first seized when by accident it is come upon.

Herrick (1903c) has made the interesting discovery that in the cat-fish, which seeks its food in the way just described, the organs of taste pervade the whole skin, and the fish will seize unseen food with great precision, provided only that it is brought near the skin. Thus in this fish the organs of taste largely replace the eye as a means of discovering the food.

From these examples it must be clear how close is the relation between sense organs and habits. The sense organs, in fact, are the usual means of initiating those simple acts which, when taken collectively, constitute what are popularly known as habits, for the sense organs are the avenues through which the external influences enter the animal and excite it to action. How essential, then, in studying the habits of any group of animals, must be a knowledge of their sense organs.

From this standpoint the elucidation of the habits of fish is particularly important, for their sense organs bear close comparison with those of human beings.

and their environment withal is so different that they afford a most fascinating field for investigation. It is now fairly well established that many fishes possess in a high functional state the five chief senses of man—taste, smell, touch, hearing, and sight; but it is also known that many fishes possess a sixth set of organs, the lateral-line organs, for which there is no representative in man. As these are well-developed and conspicuous structures in many cases, they may be suspected of playing an important part in the economy of these animals, and it is the purpose of this investigation to ascertain something of their rôle in the ordinary habits of some of our fishes.

## HISTORICAL REVIEW.

Every one who is at all conversant with the external markings of fishes is familiar with a line which, in most instances, extends along the side from tail to head. This line, known from its position as the lateral line, consists usually of a row of small pores which lead into an underlying canal, the lateral-line canal. In the head of the fish this canal usually branches into three main stems, one of which passes forward and above the eye, another forward and immediately below the eye, and a third downward and over the lower jaw. These three canals, like the lateral-line canal, open on the surface by numerous pores, and, together with this canal, constitute the lateral-line system.

According to Leydig (1868, p. 3) the pores of these canals were recognized over two centuries ago by Stenon (1664) and by Lorenzini (1678) in elasmobranchs, and by Rivinus (1687) in fresh-water fishes. Subsequently the canals were described by many of the earlier anatomists, particularly by Monro (1785), and an excellent summarized account of them was given by Stannius (1846, p. 49) in his comparative anatomy of the vertebrates. Thus before the middle of the last century the gross anatomy of these organs had come to be fairly well recognized.

All the earlier investigators, so far as their opinions are known to me, seem to have regarded the lateral-line system as a system of glands for the production of the mucus so characteristic of the skins of many fishes. Suggestions contrary to this, however, came from two sources. First, observations on elasmobranchs had shown that this group possesses, in addition to the lateral-line system proper, a set of closely related organs, the ampullæ of Lorenzini. Jacobson (1813) studied the structures of these organs with the view of determining what their probable function was, and concluded from their extensive nerve supply that they were certainly sense organs and probably stimulated mechanically, like delicate organs of touch. Treviranus (1820, p. 146), concurred in Jacobson's opinion that the ampullæ were sense organs, and believed that they probably represented a sense quite distinct from any that we possess. Knox (1825, p. 15) in reviewing the whole subject made the interesting statement that "we can not * * * greatly err in considering these organs as organs of touch, so modified, however, as to hold an intermediate place between the sensations of touch and hearing." Finally, Savi (1841) suggested that in the torpedo they might be organs for the reception of electrical stimuli.

A second body of evidence that suggested the nonsecretory nature of the lateral-line system came from investigations on the vesicles of Savi. These are closed, sac-like organs found in clusters in the anterior part of the head of the torpedo. Like the ampullæ of Lorenzini, they are undoubtedly closely related to the lateral-line system. They were originally described by Savi (1841) as nervous organs, and a sensory function was claimed for them by Wagner (1847). This opinion was subsequently supported by Schultze's discovery (1863, p. 11) that the epithelium of these organs contained an abundance of sense cells. Thus the sensory nature of the vesicles of Savi and of the ampullæ of Lorenzini was clearly in the minds of several of the earlier investigators at a time when the nearly related lateral-line system was regarded as a purely secretory mechanism.

In April, 1850, Leydig (1850a) gave a preliminary account of certain large sense organs found by him in the lateral-line canals on the head of the ruffe (*Acerina cernua*), and later in the same year he (Leydig, 1850b) figured and described these organs in detail not only in the ruffe, but in several other species of fresh-water fishes. Since he could find no reason to suppose that the slime on the surface of these fishes was produced in the lateral-line canals, and since these canals contained large sense organs, he concluded that the lateral-line system was not a set of glands, but a system of sense organs which he believed to be peculiar to fishes (Leydig, 1850b, p. 171). Shortly after this, similar organs were found by Leydig (1851) in certain marine teleosts and by Müller (1852, p. 149) in elasmobranchs; and a few years later Leydig (1857, p. 196) gave in his text-book of histology, an excellent summary of the finer anatomy of these and other closely related structures. Here he briefly discussed the function of the lateral-line organs, and expressed the belief that if they must be placed under one of the five senses as usually defined, they certainly belonged under touch, but in his opinion they were very probably representatives of a new sense especially adapted for life in the water.

A few years later Schulze (1861) showed that on the skin of very young fishes there were sense organs essentially like those described by Leydig from the lateral-line canals of mature fishes. These were so distributed as to foreshadow the lateral-line canals, and they undoubtedly represented the organs which were later to occupy these canals. Schulze further demonstrated a similar system of superficial organs in the water-inhabiting stages of amphibians, and thus showed that these organs occurred in other vertebrates than the fishes, a conclusion subsequently confirmed by Leydig (1868), who, though still holding that the lateral-line organs were closely allied to the organs of touch, regarded them as sufficiently distinct to constitute a sixth class of sense organs. Leydig also suggested the possibility that these organs might be represented in other groups of the animal kingdom than the fishes and amphibians, and went so far as to intimate that certain glandular structures in the skin of the air-inhabiting vertebrates might have been derived from them.

In a second paper Schulze (1870, p. 83) pointed out the inaccuracy of this opinion and maintained that the lateral-line organs were strictly limited to fishes and the water-inhabiting stages of amphibians. He also called attention to the important and striking similarity between the sense cells in the lateral-line organs and those in the ear as described by Schultze and by Hasse, a comparison already made by Leydig (1850b, p. 180), and he concluded that the lateral-line organs were stimulated either by mass movements of the water, as when a fish swims through this medium or a current impinges on its body, or by water vibrations whose period is longer than that of the vibrations which stimulate the ear. Notwithstanding this supposed relation to the ear. Schulze agreed with Leydig in regarding the lateral-line organs as organs of touch, though specially modified to meet the requirements of an organism living in the water.

About ten years after the appearance of Schulze's second paper, Dercum (1880, p. 154) called attention to the fact that in many fishes the lateral-line canals were almost if not entirely closed, and that in consequence water could not flow through them, as was supposed by Schulze. Dercum, however, pointed out that since many of the canals were separated from the outer water by only a layer of thin skin applied to the membrane of the canal wall, the system might be said to possess numerous drumheads through which vibrations in the surrounding water could be transmitted to the fluid within the canal, and thus these vibrations could become effective in stimulating the lateral-line organs. Dercum also suggested that the effect of the vibrations might be the more intense the more nearly perpendicular they were to the surface of the canal on which they fell, and in this way it was conceivable that a fish might orient itself in reference to the direction of the vibrations.

These views were in large part accepted by Emery (1880, p. 48), who emphasized the comparison between the lateral-line organs and the internal ear, and thus lead to the opinion subsequently expressed by Mayser (1881, p. 311), Bodenstein (1882, p. 137), and P. and F. Sarasin (1887–1890, p. 54), that the lateral-line organs were accessory ears.

Meanwhile Merkel (1880, p. 55), without knowledge of the contributions made by Dercum and by Emery, showed that it was unlikely that water could be said ever to stream through the canals, and yet he gave very good reasons for supposing that the lateral-line organs were adapted to a mechanical stimulus. From his standpoint there was insufficient ground to consider the lateral-line organs as constituting a sixth group of sense organs, and he was convinced that they were merely tactile organs somewhat modified for aquatic life.

The opinions thus far presented as to the functions of the lateral-line organs are in no instance based upon experimentation, but upon such indirect evidence as that afforded by the structure of the sense organs and of their surrounding parts.

Previous to the appearance of Fuchs's paper in 1894 very few investigators had made experiments on the lateral-line organs, and such experiments as had been undertaken were of a very simple and tentative character. The earliest of these was the work of Bugnion (1873, p. 302), who showed that a living *Proteus* was not especially sensitive to solutions of alum, salt, or weak acid applied to the lateral-line organs, but that it reacted vigorously when these organs were touched with a needle. Later de Sède (1884, p. 469) reported that fishes in which the lateral line had been cut were less successful in guiding themselves in an aquarium containing numerous obstacles than were normal fish, and he stated that in his opinion the lateral-line organs did not represent a sixth sense but were organs of touch especially concerned with directing the animals. Bateson, some years later (1890, p. 237), stated that he had been unable to get responses from fishes when food substances were tried as stimuli for the lateral-line organs, and lastly, Nagel (1894, p. 191) found no evidence that the lateral-line organs of fishes and amphibians were stimulated chemically; when the lateral-line nerves in *Barbus fluviatilis* were cut on both sides the fish apparently remained normal, but when in certain fish (Schuppfisch) the nerve of only one side was cut, a slight lack of orientation and of muscle coördination could sometimes be observed. These seem to be the only noteworthy experiments on the lateral-line organs that were carried out before the time of Fuchs's work.

Fuchs (1894, p. 467) experimented chiefly on the torpedo, a fish which possesses, in addition to the lateral-line organs proper, the vesicles of Savi and the ampullæ of Lorenzini. Fuchs cut the nerves connected with these two special sets of organs, but without being able to detect any significant change in the subsequent movements of the fish. He then exposed the nerve supplying the vesicles of Savi, and, having placed it in connection with an appropriate electrical apparatus, he found that by pressing lightly on the vesicles a reduction in the current from the nerve could be demonstrated. As this reduction is believed to indicate the transmitting activity of nerves, it follows that the pressure applied to the vesicles was probably a stimulus to them and thereby brought the nerve into action. No such results were obtained from similar experiments on the ampullæ of Lorenzini, but the nerves from the lateral-line system in *Raja clavata* and *R. asterias* also gave evidence of transmission when their terminal organs were pressed. Dilute acids and heat did not stimulate the terminal organs tested, and Fuchs (1894, p. 474) concluded that pressure was the normal stimulus in the skate for the lateral-line organs and in the torpedo for the vesicles of Savi, but not for the ampullæ of Lorenzini.

Apparently without knowledge of the work done by Fuchs, Richard (1896, p. 131) performed some experiments on the gold-fish, consisting of the removal of the scales from the lateral line and the destruction of the sense organs under these scales by cauterizing with heat, or potassic hydrate. After this operation some of the fishes were unable to keep below the surface of the water, and though they soon died, Richard (1896, p. 133) believed that he had evidence enough to show that the lateral-line organs were connected with the production of gas in the air bladder.

Richard's conclusions were called in question by Bonnier (1896, p. 917), who pointed out the severity of the operations employed and intimated that the results were more probably dependent upon the excessive amount of tissue removed than upon the destruction of the lateral line. Bonnier (1896, p. 918) further recorded experiments of his own in which the lateral-line organs were destroyed by electrocautery. Fishes thus operated upon showed two characteristics: They could easily be approached with the hand and even seized; and they failed to orient themselves in reference to disturbances caused by bodies thrown into the water. Bonnier concluded from his experiments that the lateral line, in addition to other functions, had to do with the orientation of fishes in reference to centers in the water from which shock-like vibrations might proceed.

Lee (1898, p. 139), whose experimental methods were much the same as those used by Bonnier, obtained some significant results, particularly with the toad-fish, *Opsanus tau*. When the pectoral and pelvic fins of this fish were removed, so that it might be said to be without its usual mechanical support, and the lateral-line organs were destroyed by thermo-cautery, the animal would lie quietly for some time, on either its side or back, and act as though it had lost its "sense of equilibrium." That its condition was not due to excessive injury was seen from the fact that a finless fish in which an equal amount of skin had been cauterized, but in which the lateral-line organs were intact, showed no lack of equilibrium, and in its general behavior closely resembled a normal fish. Moreover, Lee found that the stimulation of the central end of the lateral-line nerve of a dog-fish resulted in perfectly coordinated fin movements, and he therefore concluded that the organs of the lateral line are equilibration organs. How these are stimulated Lee did not attempt to decide, though he suggested (1898, p. 143) that pressure changes in the surrounding medium may be the means of stimulation.

Five years later, in experimenting on the sense of hearing in fishes, I made some observations on the lateral-line organs of *Fundulus* (Parker, 1903a, p. 59; 1903b, p. 197). These led to the conclusion that the lateral-line organs in this fish were stimulated by a very slight mass movement of the water, and they have afforded the point of departure for the present investigation.

In summarizing this historical review, it is clear that no one has ever brought forward the least reason to suspect that the lateral-line organs are ever normally stimulated by light, heat, or other ether disturbances. It is also very improbable that they are stimulated chemically, for in many instances the covered situation of the organs is not favorable for this form of stimulation, and the direct experiments of Bugnion (1873) on *Proteus*, of Bateson (1890), and of Nagel (1894) on several kinds of fish, and of Fuchs (1894) on *Torpedo* and *Raja* have always given negative results. On the other hand, it is almost universally admitted that the normal stimulus for these organs must be of a mechanical kind, either simple contact, as in touch, or vibratory contact, somewhat as in hearing. It is on this point that the majority of investigations disagree, some maintaining that the lateral-line organs are simply organs of touch (Merkel, de Sède), or of pressure (Fuchs), others that they are organs belonging to an independent class, probably intermediate between touch and hearing (Leydig, Schulze, Dercum, Parker), and, lastly, those that believe them to be accessory auditory organs (Emery, Mayser, Bodenstein, P. and F. Sarasin). That the lateral-line organs were necessary to successful locomotion as organs of equilibration, etc., was first suggested, I believe, by de Sède; and this opinion has received the support of Nagel, Bonnier, and especially of Lee. In attempting to decide between these various views, the first question that arises is: What is the normal stimulus for the lateral-line organs? It is the object of this investigation to find an answer to this question.

## MATERIALS AND METHODS.

The experiments about to be described were carried out chiefly on the common mummichog, *Fundulus heteroclitus*, a fish of convenient size, great hardiness, and everywhere abundant in the neighborhood of the biological laboratory of the United States Bureau of Fisheries at Woods Hole, Mass., where the experiments were made. Besides this species seven others were also tested, though not with a full range of stimuli. These additional species were the smooth dog-fish, *Mustelus canis;* the common skate, *Raja erinacea;* the killi-fish, *Fundulus majalis;* the scup, *Stenotomus chrysops;* the toad-fish, *Opsanus tau;* the common flat-fish, *Pseudopleuronectes americanus;* and the swell-fish, *Chylomycterus schœpfi*.

The general method of experimenting was to cut the nerves connected with the lateral-line organs of a number of individuals of a given species, and, after the fish had recovered from the operation, to test them in comparison with normal individuals by subjecting both to a particular stimulus. In this way I expected to ascertain whether with the loss of the lateral-line organs the ability to respond to certain stimuli would disappear. To eliminate the effects of the operation as far as possible I usually tested a third series of fishes in which incisions had been made to reach the nerves, but in which the nerves themselves had not been severed.

In all the fishes, except the dog-fish and the skate, the nerves were cut by the method described in my previous paper (Parker, 1903a, p. 59), i. e., the fishes were etherized by being put for a few minutes in sea water containing a little ether, and the fifth and seventh nerves were then cut by an incision behind the eye, and the lateral-line nerve by an incision just behind the head; the few lateral-line organs between these two incisions were then extripated. In the dog-fish and the skate the operation was similar, except that the fifth and the seventh nerves were more conveniently cut from the roof of the mouth than from the exterior.

The chief objection to this method of operating lies in the fact that in cutting the root of the seventh nerve it is necessary also to cut that of the fifth, so that the tactile sensibility of much of the head, as well as the innervation of the muscles of the jaws, are almost always lost. Notwithstanding the apparent severity of the operations the fishes usually recovered, and even a few hours after the operation began feeding and acted in most respects normally. The majority lived for several weeks, and some of them for over a month. Care was exercised, however, to see that they were properly fed, for the paralyzed state of the muscles of the jaws, though not interfering much with respiration, did make it difficult for the fish to grasp food.

Normal and, as I shall call them, cut fishes were then subjected to the following range of stimuli and their reactions noted: Light, heat, salinity of water, food, oxygen, carbon dioxide, foulness of water, pressure of water, currents, stimuli to equilibrium, vibrations of high frequency (sound), and vibrations of low frequency.

## EXPERIMENTS.

*Light.*—To ascertain whether light was a stimulus for the lateral-line organs the following device was used: An oblong glass aquarium, measuring about 60 cm. in length, 25 cm. in breadth, and 25 cm. in height, was half-covered with opaque cloth, so that one end and the adjacent halves of the top and of the sides were impervious to light. The apparatus was set up in a dark room and illuminated by a 16-candle incandescent electric light, so placed that the light fell across the uncovered half of the aquarium, but without entering the darkened half. The aquarium was filled with sea water and specimens of *Fundulus heteroclitus* were introduced to see if they would assemble in the light or in the dark. It was soon found that these fishes followed one another by sight, and the records finally taken came from experiments in which single fishes were put in the aquarium and their reactions observed. After a fish had become accustomed to its new surrounding, which happened usually in about ten or fifteen minutes, and which was indicated by the fish leaving the bottom of the aquarium and beginning to sport about near the surface of the water, observations were made at intervals of one minute as to whether the fish was in the dark or in the light. It soon appeared that a number of individuals were almost indifferent to the light, being found as commonly in one place as in the other. Others were more generally in the light, and fishes were tested until fifteen such were obtained. These fifteen were tested accurately by being placed individually in the aquarium and by having their positions determined at minute intervals for ten minutes. In 150 observations these fishes were 93 times (62 per cent) in the light.

They were then all operated upon by having the nerves to the lateral-line organs cut. Twelve recovered and were tested as in the first experiment. In 120 observations these fishes were 79 times (66 per cent) in the light. It is therefore highly improbable that the slight tendency to assemble in the light shown by some individuals of this species is in anyway dependent upon the lateral-line organs; in other words, light is not a stimulus for these organs.

*Heat.*—The stimulation of the lateral-line organs by heat was tested also on *Fundulus heteroclitus.* Five individuals with the nerves to the lateral-line organs cut were compared with five normal individuals by subjecting them to water of different temperatures in cylindrical glass jars 35 cm. high and 23 cm. in diameter.

The temperature of the outside water in which the fishes had been caught was at this time of year (August) about 19.5° C. When the five normal fishes were put in the glass jar filled with water at this temperature, they at once swam to the bottom, and, as is usual with them when first introduced into an aquarium, remained swimming about in the deeper water for some time. Finally, they rose to the surface and sported about in the upper water, remaining there unless frightened by some movement or other disturbance about them, whereupon they would again make a temporary descent. Cut fish acted in all respects like normal ones except, perhaps, that they were not so agile in their movements, but this slight reduction in their quickness of response was not due to the cutting of the nerves of the latteral-line system, for it was observable in fish in which the skin, but not the nerves, had been cut.

In water at 14° C., the reactions of normal and of cut fishes were indistinguishable from those in water at 19.5° C.

At 9° C., much the same was observed as at 14° C., but there was a slight though noticeably greater tendency here to keep in the deeper water than at 19.5° C. This tendency, however, was not pronounced enough to allow one to say that the fish had deserted the top; after having been frightened away from the top they returned less freely than at 14° C. or 19.5° C. In this respect, however, the normal and cut fishes agreed.

Two temperatures higher than 19.5° C. were tried. At 25.5° C. both normal and cut fishes swam down, and for the most part stayed in the deeper water. Now and then an individual would swim to the top, but it almost always quickly returned to the bottom. In these respects normal and cut fishes were indistinguishable.

At 30.5° C., both normal and cut fishes swam to the bottom of the vessel and stayed there persistently. In the course of fifteen minutes not a single fish came to the surface, whereas at 19.5° C. all fishes returned to the surface usually in three to four minutes. Moreover, the fishes continually nosed about on the bottom of the jar as though they were seeking still deeper water.

Since in all these temperature experiments the normal fish and the cut ones reacted in essentially the same way, I conclude that heat is not a stimulus for the lateral-line organs. This is in agreement with Fuchs's results (1894, p. 473) on the vesicles of Savi which were stimulated by pressure but not by heat.

The reactions of *Fundulus* to heat, though of negative value so far as the purposes of this paper are concerned, have an interesting biological bearing. It appears from the experiments given that at a temperature of 19.5° C. (corresponding to that of the outside water from which the animals had been taken), or at lower temperatures down to 9° C., the fish remain, when otherwise undisturbed, near the top of the water; but at temperatures above 19.5° C., particularly about 30° C., they seek the deeper water and remain there. In other words, they are negatively geotropic in the cooler water (9° to 19.5° C.), and become positively geotropic in the warmer water (25.5° C. to 30.5° C.), the increase of temperature causing a reversal of the sense of geotropism. This change is just the opposite of that recently pointed out by Torelle (1903, p. 475) for the frog. This animal remains near the surface of the water at high temperatures, and goes to the bottom at low temperatures, the turning point being at about 10° C. Probably these reactions, though reversed in the two instances, are not without significance for these two species. The frog may be thus protected from severe cold and the mummichog from overheated surface water.

*Salinity.*—Near the shore, and particularly near the mouths of rivers, the salinity of the sea water is subject to much variation, and it is not impossible that differences in this respect might be responded to by fishes through their lateral-line organs. Tests in this direction were made upon *Fundulus heteroclitus* by subjecting normal and cut individuals to the action of sea water variously diluted or concentrated. The sea water at the end of the government wharf at the Woods Hole laboratory is well mixed by the tides, and has the usual specific gravity of about 1.025. Water taken from this source was diluted with tap water to decrease the salinity, or concentrated by boiling to increase it. Care was taken after the boiled water had been cooled to aerate it thoroughly before it was used in experiments.

Normal and cut fishes were placed first in glass jars containing ordinary sea water and then in jars containing the diluted sea water. The fishes showed no characteristic reactions to mixtures containing 90 per cent, 80 per cent, 70 per cent, or 60 per cent of sea water. In the mixture containing half sea water and half fresh water a decided reaction was obtained in that the fishes swam about in an excited way, often with darting movements, and were as frequently found in the deeper water as near the top. Very slight evidence of this condition could at times be detected in the 60 per cent and 70 per cent mixtures, but the reactions were most decided in the 50 per cent mixture. Since the normal and the cut individuals were indistinguishable in respect to these reactions, there was no reason to suppose that the diminished salinity of the water was a stimulus for the lateral-line organs.

Both classes of fishes were put into sea water concentrated by boiling to three-fourths its original volume (the specific gravity was something over 1.030). In this water the fishes swam and respired normally, though it was evident that they were buoyed up by the greater density. Normal and cut fishes were again indistinguishable, and there was therefore no reason to suppose that the increased density had any stimulating effects on the lateral-line organs. In this respect my results agreed with those of Bugnion (1873, p. 302), who experimented with salt solutions upon the lateral-line organs of *Proteus*.

*Food.*—The normal stimulus for taste in animals, as in the human being, is the dissolved material in their food. Judging from the aquarium habits of some fishes, they seek their food chiefly by the eye, but it is also possible that the juices of the food may excite them. To ascertain whether the lateral-line organs are thus stimulated, I placed a single individual of *Fundulus heteroclitus* in a small vessel of sea water and, after it had become quiet, endeavored to discharge from a capillary tube some mussel juice on the lateral line of the body, the substance of *Mytilus edulis* being a favorite food of this fish. The extreme activity of the fish made such an experiment rather difficult, but after frequent trials on several individuals I got no results that could be said to indicate that the lateral-line organs were stimulated.

In a second set of experiments I etherized the fishes and cut the spinal cord just behind the head. After recovery, such fishes act as though the trunk muscles were paralyzed and swim about slowly by the pectoral fins. If properly fed they live for a week or more. They often rested on the bottom of the vessel in which they were kept, and when quiet afforded an excellent opportunity for testing the lateral-line organs. But even under these circumstances I never obtained reactions from these fishes that led me to conclude that the sea water decoction of mussel discharged on their lateral lines ever stimulated these organs. In this respect my results agreed with those of Bateson (1890, p. 237), and I conclude that the lateral-line organs are not stimulated by food.

*Oxygen.*—The oxygen dissolved in sea water is essential for the life of marine fishes, and as the amount varies in different parts of the sea, it is possible that this substance may serve as a stimulus to the lateral-line organs. To test this possibility, specimens of *Fundulus heteroclitus*, normal and cut, were introduced into sea water that had been boiled to expel the dissolved gases and then cooled with as little exposure to air as possible. When the fish were introduced they swam rapidly throughout the whole vessel, and their respiration was characterized by rapid and deep swallowing movements. These features disappeared very quickly on transferring the fish to ordinary sea water. Since normal and cut fishes acted alike in this experiment, there was no reason to suppose that lack of oxygen was in any way a stimulus for the lateral-line organs.

*Carbon dioxide.*—As carbon dioxide is one of the most extensive waste products from animals' bodies, it might be regarded as a possible means of polluting water, and the lateral-line organs might serve to detect this pollution. To ascertain whether carbon dioxide was a stimulus for these organs, normal and cut individuals of *Fundulus heteroclitus* were introduced into sea water through which carbon dioxide gas had been bubbling in minute streams for over half an hour. Both classes of fishes acted as though they were in ordinary sea water, and there was no reason to conclude that carbon dioxide had any effect upon the lateral-line organs.

*Foulness of water.*—A quantity of foul water taken from a vessel in which marine animals and plants were decaying was mixed with sea water and cut and normal individuals were introduced into it and their reactions observed. Although this mixture had a most offensive odor to the experimenter, the two sets of fishes behaved as though they were in ordinary sea water, and hence the general condition of foul water could not be said to afford a stimulus for the lateral-line organs.

Salts, food substances, oxygen, carbon dioxide, and the materials in foul water would probably all act as chemical stimuli on the lateral-line organs, if they acted at all, but since none of them appear to be stimuli for these organs, the observations of Bugnion (1873), Fuchs (1894), and Nagel (1894) to the effect that the lateral-line organs are not stimulated chemically, were confirmed. This view of the nonchemical reactiveness of the lateral-line organs has been clearly maintained from a morphological standpoint in two recent papers by Herrick (1903a, 1903b.)

*Pressure of water.*—Fuchs (1894, p. 474) suggested that changes in the hydrostatic pressure might be the means of stimulating the lateral-line organs. In testing this proposition normal and cut individuals of *Fundulus heteroclitus* were subjected to diminished hydrostatic pressure in a cylindrical glass museum jar three-fourths full of water. The jar was about 80 cm. high and 25 cm. in diameter, and was provided with an air-tight top. By means of a small hand pump air contained after the jar was closed was removed until the pressure was reduced from the usual 15 pounds per square inch to about 5 pounds.

When the fish were first put into the jar they all descended, as is usual, to the bottom, but after the removal of air had continued for some time they came to the top of the water, and when the pressure had fallen to about 5 pounds, it was evident that they were unable to keep below the surface of the water without vigorous and continuous swimming. Since they possess air-bladders, it seemed likely that the reduced pressure had caused such an enlargement of these organs that the fish were carried to the top of the water by their own buoyancy, and this explanation was tested by inserting capillary glass tubes into the sides of several, so that as the pressure was reduced the air could escape from the bladder. When the fish were subjected to diminished pressure under these conditions, air was seen to escape from them, and they remained quietly swimming at the bottom of the jar. Evidently the first set of fish were kept near the top of the water through their altered specific gravity. Normal and cut fishes reacted in essentially the same way in these experiments, hence there was no reason to suppose that a diminished hydrostatic pressure was a stimulus to the lateral-line organs.

In a similar way normal and cut fishes were put in a water-tight jar in which the pressure could be raised from 15 to 22 pounds on the square inch. When first introduced the fishes went to the bottom, and after the pressure was put on they remained there with the exception of short intervals, when by vigorous swimming they could get into the upper part of the jar. From such situations, however, they would often almost drop to the bottom. As in the experiments with reduced pressure, so here the air-bladder doubtless played a controlling part; for when it was punctured so that with increased pressure water could enter it, the fish swam much more freely. The increased pressure, nevertheless, stimulated the fishes, for they never seemed to come into a restful state in the fifteen minutes or so during which they were under pressure. Since the reactions of the normal and cut fishes were indistinguishable, however, there was no reason to suppose that increased hydrostatic pressure is a stimulus for the lateral-line organs.

These observations make it appear improbable that changes in hydrostatic pressure, as suggested by Fuchs (1894, p. 474), are stimuli for the lateral-line organs. Nor in fact do the observations made by Fuchs really lend much support to this hypothesis. He found that when he pressed on the lateral-line organs of *Raja*, the electrical changes in the nerves connected with them indicated that the organs had been stimulated. But the pressure thus exerted was without doubt of a very different kind from increased or decreased hydrostatic pressure; it was very probably a *deforming* pressure and not one that exerts its influence in all directions equally. It is well known that for the stimulations of the tactile organs of the human skin a deforming pressure is vastly more effective than such a pressure as is obtained by putting the hand deep in water. Under such circumstances the tactile sensations are not strongest from the parts under greatest pressure but from the region of greatest deformation, i. e., where water and air meet. It seems to me, therefore, that Fuchs's experiments demonstrate that the lateral-line organs can be stimulated by a deforming mechanical influence, but since hydrostatic pressure does not deform to any great extent, there is no reason to suppose that it stimulates these organs. Hence I do not think that my observations are at variance with those of Fuchs, but that he drew a wrong inference from what he observed.

*Currents.*—From the time of Schulze's second paper on the lateral-line organs (1870), water currents have been regarded with more or less favor as stimuli for the lateral-line organs. To ascertain whether currents do stimulate these organs, I have experimented on *Fundulus heteroclitus*, *F. majalis*, *Stenotomus chrysops*, *Pseudopleuronectes americanus*, *Mustelus canis*, and *Raja erinacea*. All these fishes when introduced into running water swim against the current, i. e., they are strongly rheotropic.

I tested the smaller species (*Fundulus heteroclitus*, *F. majalis*, *Stenotomus chrysops*, and *Pseudopleuronectes americanus*) by exposing them in a large open trough to a gentle flow of water. The trough, which was about 50 cm. wide, always contained a depth of at least 10 cm. of water and was about 3 meters in length. An inlet was established at one end and an outlet at the other, and a gentle current of water was kept flowing through the trough. A normal *Fundulus heteroclitus* when put in this trough immediately turned its head against the current and swam toward the source, often making its way actually into the open end of the inlet tube. If in its progress the fish was swept into the adjacent and more quiet water near the side of the trough, it would often sport about there for a while, but on returning to the current it would take up again its course toward the inlet. At times when the current was strong there would form on the sides of the trough small backset currents, and it was instructive to observe how quickly the fish reversed its direction when by any accident it was carried from the main current into a backset. In all the many fishes tested, irrespective of illumination, etc., they swam against the current.

Individuals in which the nerves to the lateral-line organs had been cut proved to be absolutely indistinguishable from normal fishes under these conditions. In agility and certainty of response there was no difference between the two sets. Hence I was led to conclude that the lateral-line organs were not essential to the fish in swimming against a current, and that therefore a current was probably not a stimulus for these organs.

Similar experiments were made with *Fundulus majalis* and *Stenotomus chrysops*, both of which gave results identical with those obtained from *Fundulus heteroclitus*. *Pseudopleuronectes americanus*, normal and cut, also swims against the current, but often takes hold of the bottom of the trough by a sucker-like action of the whole body. This temporary anchoring, however, was as characteristic of the cut fishes as it was of the normal ones, and there is no reason to suppose that the lateral-line organs were involved.

The larger fishes, *Mustelus canis* and *Raja erinacea*, were tested not in the trough but at one of the tide openings on the wharf outside the laboratory. Here at certain tides a steady broad current maintains itself, and in this it was comparatively easy to experiment with these fishes. Normal and cut individuals were put into a simple harness made of twine and to which a cord was attached so that they could be conveniently restrained. By this means they could be placed in the current where desired and their reactions noted. Both the dog-fishes and the skates swam vigorously against the current, and this happened irrespective of the condition of the lateral line. In fact it was impossible to tell from the reactions of the fish in the water whether the nerves to the lateral-line organs had been cut or not. My own experiments, therefore, confirm the opinion of Tullberg (1903, pp. 13, 15) that the lateral-line organs are not concerned with swimming against a current.

*Stimulus to equilibrium*.—The ability of a fish to keep its equilibrium at rest or in motion has, from time to time, been stated to be dependent at least in part on the lateral-line organs. So far as I am aware, the first investigator to make suggestions in this direction was Richard (1896, p. 131), who supposed that the lateral-line organs were at least indirectly connected with the equilibrium of a fish in that they influenced the amount of gas in the air bladder. Lee (1898, p. 144), however, first clearly expressed the belief, based upon extended observations on the toad-fish and the dog-fish, that the lateral-line organs were primarily organs of equilibration. Because of the growing favor in which this view has been held, I felt that it was desirable not only to make new observations in this direction, but also to repeat carefully the experiments of those who had already advocated this theory, with the view of gaining a critical insight into the present standing of the question. For these reasons I have carried out experiments on the equilibration function of the lateral-line organs in *Fundulus heteroclitus*, *Stenotomus chrysops*, *Opsanus tau*, and *Mustelus canis*.

When the nerves to the lateral-line organs in the species of fishes just mentioned were cut by the methods already described, and the fishes were allowed to recover from the shock of the operation, it was remarkable how little changed they seemed to be. So far as their ordinary movements were concerned they were often indistinguishable from normal fishes. They swam with agility and kept their equilibrium perfectly. My own observations entirely support Lee's statement (1898, p. 140) that the destruction of all the lateral-line organs "does not seem to interfere much, if any, with the animal's equilibrium." I usually found it impossible to bring a cut fish to rest on its side or back, for when displaced from its usual upright position it reacted as a normal fish by struggling to return to that position.

Those fishes that possess air bladders, such as *Fundulus* and *Stenotomus*, had no difficulty after the operation in keeping below the surface, and I found no reason to suppose that the lateral-line organs had any influence on the amount of gas contained in the air bladder, as conjectured by Richard (1896). In fact, all my observations supported Bonnier's opinion that Richard's results were due to the severity of his operations and not to the loss of the lateral-line organs, and since many fishes with well-developed lateral-line systems have no air bladders, it seems to me highly improbable that these sense organs are directly concerned with the state of the bladder.

I next repeated Lee's experiments on the toad-fish, *Opsanus tau*, and the dog-fish, *Mustelus canis*. Lee (1898, p. 140) states that after the removal of the pectoral and pelvic fins from the toad-fish, the natural means for support for the resting animal, and the destruction of the lateral line organs, there were "decided evidences of a lack of the sense of equilibrium." The fishes were unsteady in their movements and would lie quietly upon the side or back, in this respect being in strong contrast with individuals whose fins and skin had been cut to an equal extent, but whose lateral-line systems were still intact. These, according to Lee, were active and certain in their movements, showed no lack of equilibrium, and in general closely resembled normal individuals.

My own observations on *Opsanus* do not support those of Lee. I prepared six toad-fish by cutting off the four fins as Lee did and then severing the nerves to the lateral-line organs. This operation was easily carried out by following the careful topographical account of the lateral-line system given for this species by Clapp (1898). Of the six fishes operated upon one died shortly after the operation but the remaining five all lived over five days and one over a week. These I carefully compared with five other fishes from which the four fins had been removed and the skin, but not the nerves to the laterial-line organs, had been cut. So far as the retention of equilibrium was concerned, I found it impossible to distinguish one set from the other. Both, though rather irregular in their locomotion, retained fairly upright positions, and none ever showed the characteristic disturbances seen in the locomotion of many fishes from which the ears have been removed. Occasionally individuals could be found that would lie quietly often for some time on the side or back, as described by Lee, but these always proved to be moribund and usually died within a day or so after this symptom appeared. Since cases of this kind occurred among those fishes in which the lateral-line organs were intact, as well as among those in which the nerves had been cut, I concluded that the loss of equilibrium seen in these instances was not due to the exclusion of the lateral-line system, but to general weakness preceding death. I therefore do not believe, as Lee does, that the loss of the lateral-line organs in *Opsanus* is accompanied with any special disturbance in equilibrium.

Lee (1898, p. 142) also experimented upon the dog-fish by exposing the lateral-line nerve and stimulating its central end, whereupon he obtained well coordinated muscular movements like those seen on stimulating the ampullar organs of the internal ear. I have repeated this experiment on *Mustelus canis* and can confirm Lee's statements even to detail. I have worked with care only on the pectoral-fin reactions, but these will suffice to give a clear insight into the nature of the response. When, as Lee states (1898, p. 142), the left lateral-line nerve is stimulated centrally, the left pectoral fin is elevated and the right depressed. Since this reaction, which is always very marked and clear, is of a kind to restore equilibrium, one might conclude with Lee that the lateral-line organs are organs of equilibration, but exactly the same reaction can be called forth by touching the skin with the electrodes. If the lateral-line nerve is cut on one side of the body and the electrodes are applied on that side and at a point posterior to the cut, the pectoral-fin reactions that occur are the same as those seen when the lateral-line nerve is stimulated centrally. Since the pectoral-fin reactions thus obtained disappear when the spinal cord anterior to the region of stimulation is cut, there can be no doubt that the general cutaneous terminations of the spinal nerves are the recipients of the stimulus. Hence Lee's conclusion that the lateral-line organs are organs of equilibration must be qualified by the statement that there is no reason to suppose that these organs are more concerned with this function than is the integument. This opinion is supported by certain observations made by Lyon (1900, p. 79) to the effect that when the tail of a dog-fish is turned laterally, compensating movements of the eyes can be observed even though the second and eighth nerves are cut. Since these movements disappear on cutting the spinal cord, Lyon concludes that the afferent path is from the sensory nerves of the skin or muscle.

So far as equilibration is concerned, the lateral-line organs are certainly much inferior to the ear and even the eye. Thus if the nerves to the lateral-line organs of a dog-fish are cut, the animal will continue to swim as a normal individual does. If the eyes are covered, normal swimming still continues. But if the eighth nerve of a dog-fish is cut, and the animal is made to swim rapidly, it will usually lose its equilibrium even with the whole lateral-line system intact, and if the eyes are covered it invariably does so. Thus while the eye may in part supplement the ear in orientation, the lateral-line organs seem to be of no significance in this respect, and our only reason for supposing that they are of value in equilibrium is the fact that on stimulating the lateral-line nerve, fin movements, etc., occur such as are produced by stimulating the ampullar organs of the ear; but this does not raise them as organs of equilibration to an order higher than that of the skin. Since in this respect they are much inferior to the internal ear, it is misleading to designate them as special equilibration organs.

*Vibrations of high frequency (sound).*—The suggestion made by Emery (1880), Mayser (1881), Bodenstein (1882), and others, that the lateral-line organs may be accessory ears, calls for a test of these organs by sounds. To carry out this I used the same apparatus that I had formerly employed to test the sense of hearing in fishes (cf. Parker, 1903a, 1903b). This consisted of a marine aquarium, one end of which was made of wood and in which was hung a smaller glass aquarium closed at one end (that next the wooden end of the large aquarium) by a silk net of coarse mesh. Thus the fish could be restrained in the smaller aquarium and yet be subjected to sound from the sounding-board at the end of the larger one. As a source of sound I used a tuning fork driven by electricity and giving out 100 vibrations per second. It was placed on an isolated base so near the sounding-board that a very slight movement was sufficient to bring it into contact with the board, and thus the sound could be conveyed to the water. Experiments were made on *Fundulus heteroclitus*, *F. majalis*, *Stenotomus chrysops*, and *Mustelus canis*.

My experiments on *Fundulus heteroclitus* confirm my results of a year ago (Parker, 1903a, p. 56; 1903b, p. 199). When normal individuals of this species were stimulated by sound they often responded by pectoral fin movements and almost invariably by an increase in their respiratory rate. This continued to be true even after the nerves to the lateral-line organs had been cut, and I therefore concluded that the lateral-line organs were not essential to these responses. Since the pectoral fin and the respiratory reactions disappeared in individuals whose eighth nerves had been cut, but whose lateral-line organs were intact, it was evident that while in this species these sounds were effective stimuli for the ear they were not so for the lateral-line organs.

*Fundulus majalis* reacts in many respects like *F. heteroclitus.* Its movements, however, are often more sudden and darting than in the other species. To vibrations of the tuning fork the animals usually spread the fins and often gave a short dart forward. This continued after the nerves to the lateral-line organs had been cut, and ceased only with the cutting of the eighth nerve; hence I conclude that also in *F. majalis* sound is a stimulus for the ear but not for the lateral-line organs.

Although I tested a considerable number of *Stenotomus chrysops* and *Mustelus canis*, both in normal condition and with their lateral-line nerves cut, I was unable to elicit from them any unquestionable reactions to the sound from the tuning fork. This stimulus certainly did not act on the lateral-line organs of these two fishes, and from the experiments on the two species of *Fundulus*, I conclude that there is no reason to suppose that a sound of 100 vibrations per second is a stimulus for the lateral-line organs, though it may be for the ear.

*Vibrations of low frequency.*—When a slow but noiseless vibration was given to the aquarium containing *Fundulus heteroclitus*, the fishes, as I have elsewhere stated (Parker, 1903a, 1903b), were vigorously stimulated. The stimulus that affects them seemed to proceed from a movement of the body of water in the aquarium as a whole, for the most convenient way to produce this stimulus was to make the aquarium and the supporting table vibrate slightly by drawing the aquarium a little to one side, thus straining the table slightly, and then letting it go. The motion thus produced, when written off on a moving surface, was found to consist of a series of vibrations very close to six per second, and each time the aquarium was made to vibrate, about forty such vibrations were accomplished before the apparatus came to rest again.

I have nothing to add to my former statements (Parker, 1903a, p. 59; 1903b, p. 199) about the reactions of *Fundulus heteroclitus* to this stimulus. When normal individuals are first introduced into an aquarium they swim at once to the bottom, and only after some time and numerous cautious attempts do they come to swim at the surface. As I have already noted, any slight disturbance, such as a quick movement of the observer or a slight jar given to the aquarium, is sufficient to cause them to descend at once. If, by means invisible to the fishes, the slow vibration already described is given to the aquarium, they dart at once to the bottom and remain there some time before returning to the surface. When the fish again begin to swim upward toward the surface, their progress may at any moment be stopped by causing the aquarium to vibrate, for they will again descend. Under no circumstances will the normal fishes rise and stay at the surface while the aquarium is in vibration. These reactions are in my experience practically invariable.

When individuals with the nerves to the lateral-line organs cut are subjected to similar tests, the contrast with normal fishes is striking. Cut fishes will continue to sport about near the surface, or even swim upward from below, while the aquarium is in vibration. In fact the vibration seems to have no effect upon them except in that it produces ripples on the top of the water, and when they come under the influence of these they usually descend a few inches into water which, so far as one can judge from the particles of silt contained in it, is not in motion from the surface ripples. Here they will remain and sport about during the vibrations, though this region would be immediately deserted by a normal fish. Hence I conclude that a body of water vibrating at a relatively slow rate, six per second, is a stimulus for the lateral-line organs in *Fundulus heteroclitus.*

The reactions of *Fundulus majalis* to vibrations of low frequency, except for the darting movements already mentioned, were almost identical with those of *F. heteroclitus.* Normal individuals reacted to the vibrations usually at once by descending; cut ones gave no evidence of being stimulated. In one set of the normal fishes that were being tested preparatory to operations two were found that could not be said to respond to the vibrations. Such conditions were never met with in *F. heteroclitus*, and they were so rare in *F. majalis* that they constitute an unimportant exception to the statement that the two species in their lateral-line reactions are essentially alike.

*Stenotomus chrysops* when put in the aquarium usually swam down to the bottom and remained in the deeper water, sometimes with the lower fins in contact with the floor of the aquarium, sometimes a few inches above this. In all tests of vibrations made with these fishes, care was taken that the stimulus should be applied only when the fishes were not in contact with any solid body, i. e., when they were suspended somewhat above the bottom of the aquarium. Under such circumstances a noiseless vibration almost invariably called forth a very characteristic reaction. When quietly suspended in the water the fish usually rests with its head pointed obliquely downward and its tail up. On stimulating it with a vibration it almost invariably sets its fins and changes the direction of its axis so that its head points obliquely upward. This was observed clearly in six out of seven normal fishes. These six were then operated upon by cutting the nerves to the lateral-line organs. Five recovered, and none of these reacted to the vibrations of low frequency unless the aquarium was made to vibrate very considerably. Under such circumstances occasional, but unquestionable, reactions, precisely like those just described, were observed. Since these reactions are not interfered with by cutting the eighth nerves, and occur when the literal-line organs are excluded, it is probable that they result from a stimulation of the general cutaneous nerves. Thus in *Stenotomus chrysops* one form of stimulus is probably effective for two sets of sense organs, those of the skin and those of the lateral-line system.

In testing the smooth dog-fish, *Mustelus canis*, for reactions to vibrations of low frequency, I found the ordinary individuals too large for work in the aquarium, and I therefore experimented on young animals not over a foot and a half in length. As already noted, none of the specimens I tested gave any response to the tuning fork at 100 vibrations per second. To the slower vibrations, six per second, all fishes tested were very responsive and reacted usually in a very uniform way. In seven young fishes that were tested all raised the tail when the aquarium was made to vibrate, and if the fishes were high in the water they usually swam to the deeper situations. These reactions, particularly the elevation of the tail, were unusually regular. I noticed no change in the respiratory rate. It was with difficulty that even these young fishes were tested, for, since they were relatively large, it was only now and then that they were not in contact with solid parts of the acquarium, and consequently in position for satisfactory stimulation. Notwithstanding this difficulty, however, enough unquestionable reactions were obtained to place beyond doubt the statements made above.

After the nerves to the lateral-line organs were cut, both the elevation of the tail and the downward swimming ceased. To ascertain how much of the loss of response was due to the cutting of the skin, etc., I made the necessary skin apertures for cutting the nerves in one individual, but did not sever the nerves, and then tested the animal. It still elevated the tail with great regularity on stimulation. On cutting the nerves this reaction entirely disappeared. Hence I believe the loss of reactiveness is due to the elimination of the lateral line organs and not to the shock of the operation. Six of the seven dog-fishes operated upon recovered, and most of them lived for two or three weeks after the operations. When tested toward the end of this period they were as characteristic as they were a short time after recovery.

I attempted similar experiments with small skates, *Raja erinacea*, and succeeded in getting on stimulation excellent tail reactions like those described for the dog-fish, but since these fishes were always in contact with the solid bottom of the aquarium it was impossible to say with certainty that they were not directly stimulated through their tactile organs. On cutting the nerves to the lateral-line organs, however, these tail reactions disappeared. Although I believe it would be hazardous to draw any conclusion from the experiments on the skate just recorded, the records on the four other species of fishes tested show beyond a doubt that the lateral-line organs are stimulated by water vibrations at the rate of 6 per second, though they are not stimulated when the rate reaches 100 per second.

## DISCUSSION OF RESULTS.

From the foregoing experiments I conclude that the lateral-line organs of the species of fishes experimented upon are not stimulated by light, heat, salinity of water, food, oxygen, carbon dioxide, foulness of water, pressure of water, currents, and sounds. They are stimulated by vibrations of low frequency, as surmised by Schulze (1870), and these may be of service to the fishes in their orientation and equilibration reflexes, as suggested by de Sède (1884), Bonnier (1896), and especially by Lee (1898). There is, however, no reason so far as I can discover, for designating these organs as special organs of equilibration such as the ear, for in this respect they are of no higher value than the skin, and they are certainly inferior to the eye.

The stimulus for the lateral-line organs (a water vibration of low frequency) is a physical stimulus intermediate in character between that effective for the skin (deforming pressure of solids, currents, etc.) and that for the ear (vibrations of high frequency), and indicates that these organs hold an intermediate place between the two sets of sense organs named. This opinion, even from an actual genetic standpoint, has already been urged by many observers. Leydig (1850 b, p. 180) long ago pointed out the histological similarity between the sense organs of the internal ear and those of the lateral-line system; and Schulze (1870) emphasized this relation and brought into strong contrast the histological differences between the organs of the ear and the lateral-line system and those of the sense of taste, a contrast strengthened by the recent work of Herrick (1903a, 1903b, 1903c).

The innervation of the lateral-line organs and of the ear also supports the belief in the genetic relations of these parts. Mayser (1881, p. 311) first pointed out the interesting fact that the nerves from the lateral-line organs and from the ear all terminate in one central structure, the so-called tuberculum acusticum, and this observation has been confirmed and its significance admitted by almost all subsequent investigators.

The development of the ear and of the lateral-line organs has led to still more important results, however, for in this way it has been shown that both sets of organs are derived from the skin, and that the relations of the ear to the lateral-line organs are such that, as Beard (1884, p. 143) declared, the ear may be regarded as a modified part of the lateral-line system. This opinion was accepted by Ayers (1892, p. 306) in his interpretation of the work of Allis (1889), and has been maintained recently by Cole (1898, p. 197) as now fully established, notwithstanding the fact that in some fishes, like *Amia*, the ear and lateral-line organs develop separately (Beckwith, 1902).

Finally, the physiological evidence shows that these organs are intermediate in character between the skin and the ear, and support the conclusion elsewhere expressed (Parker, 1903b, p. 198), that together these sense organs represent what may be figuratively spoken of as three generations, in that the skin represents the first generation, which gave rise to the lateral-line organs, from which in turn came the ear. Thus the organs of touch, of the lateral-line system, and of the ear form a natural group, genetically connected as just indicated.

It may well be asked what disturbances in the water under natural conditions give rise to stimuli for the lateral-line organs. To determine this I tried some experiments with normal and cut *Fundulus heteroclitus*. It seemed to me probable, since the vibratory stimulus for the lateral-line organs was usually accompanied by ripples on the surface of the water, that by blowing on the water and producing strong ripples a movement might be induced in the deeper water sufficient to stimulate the lateral-line organs. This was tested by putting normal fish one at a time in an aquarium about a foot deep and blowing on the surface of the water till strong ripples were produced. All the fishes invariably went to the bottom and stayed there while the water remained agitated. These fishes were then cut, and after recovery again tested. While none of them would stay in the superficial water obviously in motion, as, in fact, was to be expected, none sought the bottom as they formerly had done, and there was no doubt left in my mind that when wind blows upon the surface of water it causes a motion of the deeper water, which stimulates the lateral-line organs. If this be true it follows that the more active fishes should have better developed lateral-line organs than the more sluggish bottom ones, and, at least so far as sharks and rays are concerned, this has been claimed to be so by Garman (1888, p. 65) and by Ewart (1892, p. 81).

I also tried the effects on normal and cut *Fundulus heteroclitus* of dropping unseen objects into the water. This was done with as little noise as possible, and almost always was followed by a sudden spring on the part of a normal fish generally away from the center of disturbance, so that I am led to conclude that the disturbances set up by such an object as a stone falling into the water stimulate the lateral line organs and with more or less directive effect, as surmised by Bonnier (1896).

That the movements generated in the water by the male *Polyacanthus* when mating are stimuli for the lateral line organs of the female, as suggested by Stahr (1897), may be true, but is unsupported by any proof.

So far as these observations go they show that surface wave movements, whether produced by moving air on the water or solid bodies falling into the water, are accompanied by disturbances which are stimuli for the lateral-line organs. This doubtless is the most usual form of stimulus for these organs in surface fishes, for I have shown that currents and direct wave action are probably not effective in this respect.

### SUMMARY.

1. The lateral-line organs are not stimulated by light, heat, salinity of water, food, oxygen, carbon dioxide, foulness of water, water pressure, water currents, and sound.

2. The lateral-line organs are stimulated by water vibrations of low frequency—six per second.

3. The lateral-line organs may be of service to the fish in orientation, but they are of no more significance in equilibration than the skin, and are inferior in this respect to the eye and the ear.

4. Waves on the surface of the water produced by air currents and the disturbances made by bodies falling into the water produce vibrations in the deeper water that stimulate the lateral-line organs.

5. The skin, the lateral-line organs, and the ear form a natural group of sense organs whose genetic relations are such that the skin (organs of touch) may be said to be the first generation from which the lateral-line system has been derived, and this in turn has given rise to the ear.

### LIST OF REFERENCES.

ALLIS, E. P.

1889. The anatomy and development of the lateral-line system in Amia calva. Journal of Morphology, vol. 2, no. 3, pp. 463–566, pls. 30–42.

AYERS, H.

1892. Vertebrate Cephalogenesis. II. A contribution to the morphology of the vertebrate ear, with a reconsideration of its functions. Journal of Morphology, vol. 6, no. 1, pp. 1–360, pls. 1–12.

BATESON, W.

1890. The sense organs and perceptions of fishes; with remarks on the supply of bait. Journal of the Marine Biological Association, new series, vol. 1, pp. 225–256, pl. 20.

BEARD, J.

1884. On the segmental sense organs of the lateral line, and on the morphology of the vertebrate auditory organ. Zoologischer Anzeiger, Jahrg. 7, no. 161, pp. 123–126; no. 162, pp. 140–143.

BECKWITH, C. J.

1902. The early history of the lateral line and auditory anlages in Amia. Science, new series, vol. 15, p. 575.

BODENSTEIN, E.

1882. Der Seiterkanal von Cottus gobio. Zeitschrift für wissenschaftliche Zoologie, Bd. 37, Heft 1, pp. 121–145, Taf. 10.

BONNIER, P.

1896. Sur le sens latéral. Comptes rendus des Séances et Mémoires de la Société de Biologie, série 10, tome 3, pp. 917–919.

BUGNION, E.

1873. Recherches sur les organes sensitifs qui se trouvent dans l'epiderme du protée et de l'axolotl. Bulletin de la Société Vaudoise des Sciences Naturelles, série 2, vol. 12, no. 70, pp. 259–316, pls. 11–16.

CLAPP, C. M.

1898. The lateral-line system of Batrachus tau. Journal of Morphology, vol. 15, no. 2, pp. 221–264, pls. 19–20.

COLE, F. J.

1898. Observations on the structure and morphology of the cranial nerves and lateral sense organs of fishes; with special reference to the genus Gadus. Transactions of the Linnean Society of London, series 2, zoology, vol. 7, pt. 5, pp. 115–221, pls. 21–22.

DERCUM, F.

1880. The lateral sensory apparatus of fishes. Proceedings of the Academy of Natural Sciences of Philadelphia, 1879, pp. 152–154.

EMERY, C.

1880. Le Specie del Genere Fierasfer nel Golfo di Napoli e Regioni limitrofe. Fauna und Flora des Golfes von Neapel, 2 Monographie, 76 pp., 9 tav.

EWART, J. C.

1892. The lateral sense organs of Elasmobranchs. I. The sensory canals of Laemargus. Transactions of the Royal Society of Edinburgh, vol. 37, pt. 1, nos. 5–6, pp. 59–85, pls. 1–2.

FUCHS, S.

1894. Ueber die Function der unter der Haut liegenden Canalsysteme bei den Selachiern. Archiv für die gesammte Physiologie, Bd. 59, pp. 454–478, Taf. 6.

GARMAN, S.

1888. On the lateral canal system of the Selachia and Holocephala. Bulletin of the Museum of Comparative Zoology, Harvard College, Cambridge, vol. 17, no. 2, pp. 57–119, 53 pls.

HERRICK, C. J.

1903a. On the phylogeny and morphological position of the terminal buds of fishes. Journal of Comparative Neurology, vol. 13, no. 2, pp. 121–156.

1903b. On the morphology and physiological classification of the cutaneous sense organs of fishes. American Naturalist, vol. 37, no. 437, pp. 313–318.

1903c. The organ and sense of taste in fishes. Bulletin of the United States Fish Commission for 1902, pp. 237–272.

JACOBSON, L.

1813. Extrait d'un Memoire sur une organe particulière de sens dans les raies et les squales. Nouveau Bulletin des Sciences, par la Société philomatique de Paris, tome 3, no. 72, pp. 332–337.

KNOX, R.

1825. On the theory of the existence of a sixth sense in fishes; supposed to reside in certain peculiar tubular organs, found immediately under the integuments of the head in sharks and rays. The Edinburgh Journal of Science, vol. 2, pp. 12–16, pl. 2, figs. 18–19.

LEE, F. S.

1898. The functions of the ear and the lateral line in fishes. American Journal of Physiology, vol. 1, no. 1, pp. 128–144.

Leydig, F.

1850a. Vorläufige Notiz über ein eigenthümliches Verhalten der Nerven in den Schleimcanälen des Kaulbarsches. Tagesberichte über die Fortschritte der Natur- und Heilkunde (R. Froriep), Abtheilung Zoologie und Paläontologie, Bd. 1, no. 79, pp. 121–122.

1850b. Ueber die Schleimkanäle der Knochenfische. Archiv für Anatomie, Physiologie, und wissenschaftliche Medicin, Jahrg. 1850, pp. 170–181, Taf. 4, fig. 1–3.

1851. Ueber die Nervenknöpfe in den Schleimkanälen von Lepidoleprus, Umbrina und Corvina. Archiv für Anatomie, Physiologie, und wissenschaftliche Medicin, Jahrg. 1851, pp. 235–240, Taf. 9, fig. 1–2.

1857. Lehrbuch der Histologie des Menschen und der Thiere. Frankfurt a. M., $8^{vo}$, xii + 551 pp.

1868. Ueber Organe eines sechsten Sinnes. Verhandlungen der Kaiserlich Leopodinisch-Carolinischen Deutschen Akademie der Naturforscher, Bd. 34, no. 5, 108 pp., 5 Taf.

Lorenzini, S.

1678. Osservazioni intorno alle Torpedini. In Firenze per l' Onofri, 1678. (Cited from Leydig, 1868, p. 3.)

Lyon, E. P.

1900. Compensatory motions in fishes. American Journal of Physiology, vol. 4, no. 2, pp. 77–82.

Mayser, P.

1881. Vergleichend anatomische Studien über das Gehirn der Knochenfische mit besonderer Berücksichtigung der Cyprinoiden. Zeitschrift für wissenschaftliche Zoologie, Bd. 36, Heft 2, pp. 259–364, Taf. 14–23.

Merkel, F.

1880. Ueber die Endigungen der sensiblen Nerven in der Haut der Wirbelthiere. Rostock, $4^{to}$, 214 pp., 15 Taf.

Monro, A.

1785. The structure and physiology of fishes explained and compared with those of man and other animals. Edinburgh, fo., 128 pp., 44 pls.

Müller, H.

1852. Die nervösen Follikel-Apparat der Zitterrochen und die sogenannten Schleimkanäle der Knorpel-Fische. Verhandlungen der physikalisch-medicinischen Gesellschaft in Würzburg, Bd. 2, pp. 134–149.

Nagel, W. A.

1894. Vergleichend physiologische und anatomische Untersuchungen über den Geruchs- und Geschmackssinn. Bibliotheca Zoologica, Heft 18, xiii + 207 pp., 7 Taf.

Parker, G. H.

1903a. Hearing and allied senses in fishes. Bulletin of the United States Fish Commission for 1902, pp. 45–64, pl. 9.

1903b. The sense of hearing in fishes. American Naturalist, vol. 37, no. 435, pp. 185–204.

Richard, J.

1896. Sur les fonctions de la ligne latérale du Cyprin doré. Comptes rendus des séances et Mémoires de la Société de biologie, série 10, tome 3, pp. 131–133.

Rivinus, A. Q.

1687. Observatio anatomica circa poros in piscium cute notandos. Acta erudítor, Lipsiæ, 1687, pp. 160–162. (Cited from Leydig, 1868, p. 3.)

Sarasin, P., and F.

1887–1890. Zur Entwicklungsgeschichte und Anatomie der ceylonesischen Blindwühle Ichthyophis glutinosus, L. Ergebnisse naturwissenschaftlicher Forschungen auf Ceylon, Bd. 2, 263 pp., 3 Taf.

Savi, P.

1841. Osservazioni sul sistema nervoso dell' organo elettrico della Torpedine. Atti della terza Reunione degli Scienziati italiani, tenuta in Firenze, 1841, pp. 328–329, 334–337.

SCHULTZE, M.
1863. Untersuchungen über den Bau der Nasenschleimhaut. Abhandlungen der naturforschenden Gesellschaft zu Halle, Bd. 7, pp. 1–100, Taf. 1–5.

SCHULZE, F. E.
1861. Ueber die Nervenendigung in den sogenannten Schleimkanälen der Fische und über entsprechende Organe der durch Kiemen athmenden Amphibien. Archiv für Anatomie, Physiologie, und wissenschaftliche Medicin, Jahr. 1861, pp. 759–769, Taf. 20.
1870. Ueber die Sinnesorgane der Seitenlinie bei Fischen und Amphibien. Archiv für mikroskopische Anatomie, Bd. 6, pp. 62–88, Taf. 4–6.

DE SÈDE, P.
1884. La ligne latérale des poissons osseux. Revue scientifique, série 3, tome 7, no. 15, pp. 467–470.

STAHR, H.
1897. Zur Funktion der Seitenorgane. Biologisches Centralblatt, Bd. 17, no. 7, pp. 273–282.

STANNIUS, H.
1846. Lehrbuch der vergleichenden Anatomie der Wirbelthiere. Berlin, 8vo, xii+482 pp.

STENON, N.
1664. De musculis et glandulis observationum specimen cum epistolis duabus anatomicis. Amstelodami, 1664. (Cited from Leydig, 1868, p. 3.)

TORELLE, E.
1903. The response of the frog to light. American Journal of Physiology, vol. 9, no. 6, pp. 466–488.

TREVIRANUS, G. R.
1820. Ueber die Nerven des fünften Paars als Sinnesnerven. In Vermischte Schriften anatomischen und physiologischen Inhalts. Von G. R. Treviranus und L. C. Treviranus. Bd. 3, pp. 135–146.

TULLBERG, T.
1903. Das Labyrinth der Fische, ein Organ zur Empfindung der Wasserbewegungen. Bihang till Kungliga Svenska Vetenskaps-Akademiens Handlingar, Bd. 28, Afd. 4, no. 15, 25 pp.

WAGNER, R.
1847. Ueber den feineren Bau des electrischen Organs im Zitterrochen. Abhandlungen von der Königlichen Gesellschaft der Wissenschaften zu Göttingen, Bd. 3, pp. 141–166.

# ISOPODS FROM THE ALASKA SALMON INVESTIGATION.

By HARRIET RICHARDSON, Ph. D.,
*Collaborator, Smithsonian Institution.*

# ISOPODS FROM THE ALASKA SALMON INVESTIGATION.

By HARRIET RICHARDSON, Ph. D.,
*Collaborator, Smithsonian Institution.*

The present paper is one of a series based on the collections of the Fisheries steamer *Albatross* in Alaska, while engaged in the salmon investigation during the summer of 1903. Four new species of Isopoda are described herein, one of which is the type of a new genus. A list of other Isopoda collected during the expedition is given and *Rocinela angustata* Richardson is figured again.

## FLABELLIFERA OR CYMOTHOIDEA.

### Family ÆGIDÆ.

**Æga symmetrica** Richardson, new species.

Body ovate, twice as long as broad. Color yellow, densely covered with light brown dots, which form a regular line along the margin of each segment. Surface smooth.

Head with frontal margin produced in a median point, which arches over the basal joints of the antennæ and meets the frontal lamina or interantennal plate on the under side. The eyes are narrow and elongate, composed of numerous ocelli. They are separated in front by a distance equal to the length of one eye. The first pair of antennæ extend to the posterior margin of the first thoracic segment; the joints of the peduncle are not dilated, although the first two joints are somewhat wider than the third, nor is there a process at the distal extremity of the second joint. The first two joints are of equal length; the third is as long as the first two together; the flagellum is composed of eleven joints. The second pair of antennæ reach the middle of the third thoracic segment; the flagellum is composed of sixteen joints. The frontal lamina or interantennal plate is conical, with the distal end flat, the proximal end produced to an acute point.

The several segments of the thorax are about equal in length, the last one being slightly shorter. The epimera are large, subquadrate, with the outer distal angle of the last three produced posteriorly beyond the margin of their respective segments.

The first three pairs of legs have the propodus beset with three small spines along the inner margin; the carpus is short and armed with one spine; the merus is provided with five spines, and the ischium has one long spine at the outer distal angle. The following four pairs of legs are long and slender furnished with hairs at the distal extremity of the joints and armed with a few spines.

The first five segments of the abdomen are short; the first is the shortest and the fifth the longest in the median dorsal line. The terminal or sixth segment of the abdomen is linguiform and rounded posteriorly with serrulated margin.

The uropoda extend a little beyond the posterior margin of the terminal abdominal segment; the outer branch is narrow, ovate, and pointed at the distal extremity; the inner branch is almost twice as wide as the outer one; both have serrulated margins.

Four specimens come from Albatross station 4228, vicinity of Naha Bay, Behm Canal, Southeast Alaska, and one from Albatross station 4199, Queen Charlotte Sound, off Fort Rupert, Vancouver Island, British Columbia, at depths of 41 to 107 fathoms. The type specimen is in the U. S. National Museum (Cat. No. 29247). The following note by Mr. Harold Heath accompanies the Fort Rupert specimen: "Eyes black. Rusty brown spots on dorsal surface. Vermilion colored ovary (?) shows through translucent cuticle."

Only two other species of *Æga* are known in the Pacific coast fauna, *Æga lecontii* (Dana*) and *Æga microphthalma* Dana †. The present species differs from *Æga lecontii* (1) in the greater length of both pairs of antennæ; those of the first pair reach to the posterior margin of the first thoracic segment, instead of to the end of the peduncle of the second pair or almost to the posterior margin of the head, and those of the second pair reach to the middle of the third thoracic segment instead of almost to the posterior margin of the first; (2) in having neither the basal joint of the peduncle of the first pair of antennæ greatly dilated nor the second joint with a process at the apex extending nearly the length of the third joint; (3) in the much shorter body, as compared with the width; (4) in having the ter-

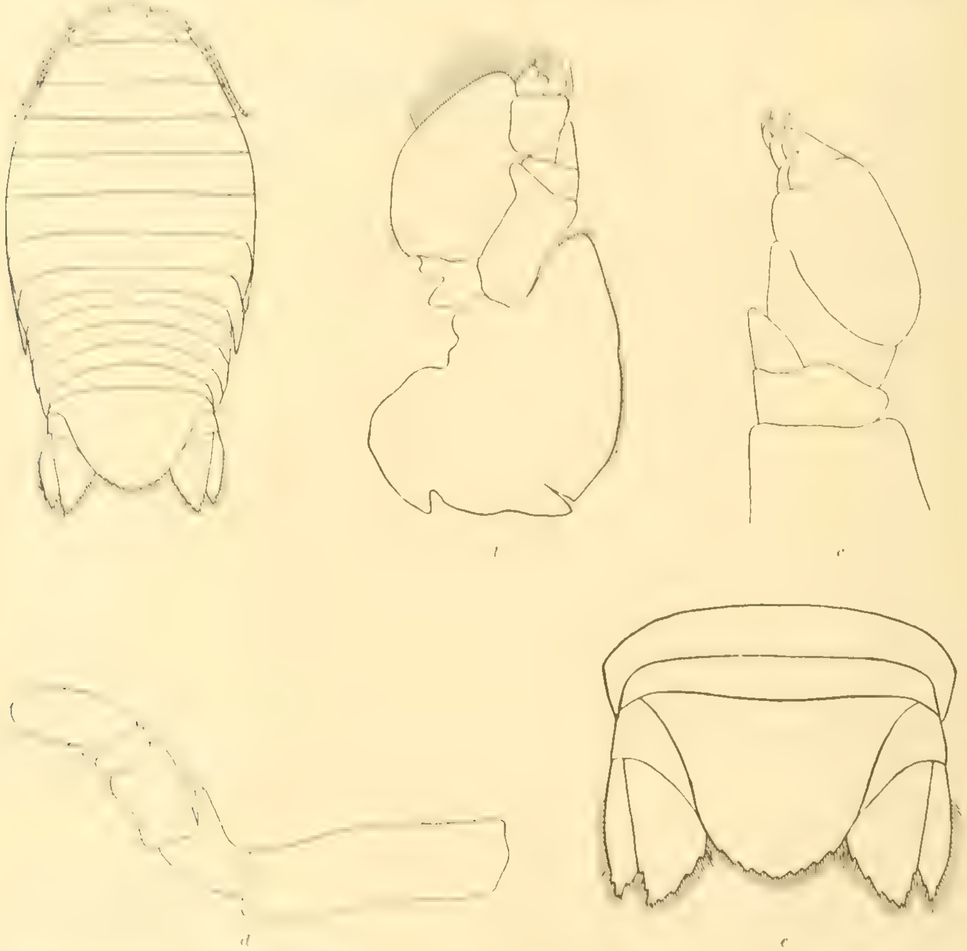


FIG. 1.—*Æga symmetrica* Richardson, new species. *a*, General view, × 4; *b*, maxilliped, × 11; *c*, maxilliped, × 77; *d*, leg of third pair, × 18⅓; *e*, last three segments of abdomen with uropoda, × 8⅓.

---

*See Proc. U. S. Nat. Museum, XXI, 1899, pp. 826–827.

†See Proc. Acad. Nat. Sci. Phil., VII, 1854, p. 176.

minal segment rounded, not truncate, at the apex; (5) in the longer uropoda; (6) in having the median point of the frontal margin of the head arch over the basal joints of the antennæ to meet the frontal lamina on the ventral side, and (7) in the different shape of the frontal lamina.

The present species differs from *A. microphthalma* in the longer first pair of antennæ, which reach the posterior margin of the first thoracic segment; in Dana's species they are shorter than the basal part (peduncle) of the external or second pair of antennæ; in the larger eyes, which are narrow and elongate, instead of being round and very small; in the longer uropoda, the branches in *A. microphthalma* scarcely surpassing the abdomen; in not having the apex of the inner branch "faintly arcuate obliquely," and in having all six segments of the abdomen visible in a dorsal view, only four being apparent in *A. microphthalma.*

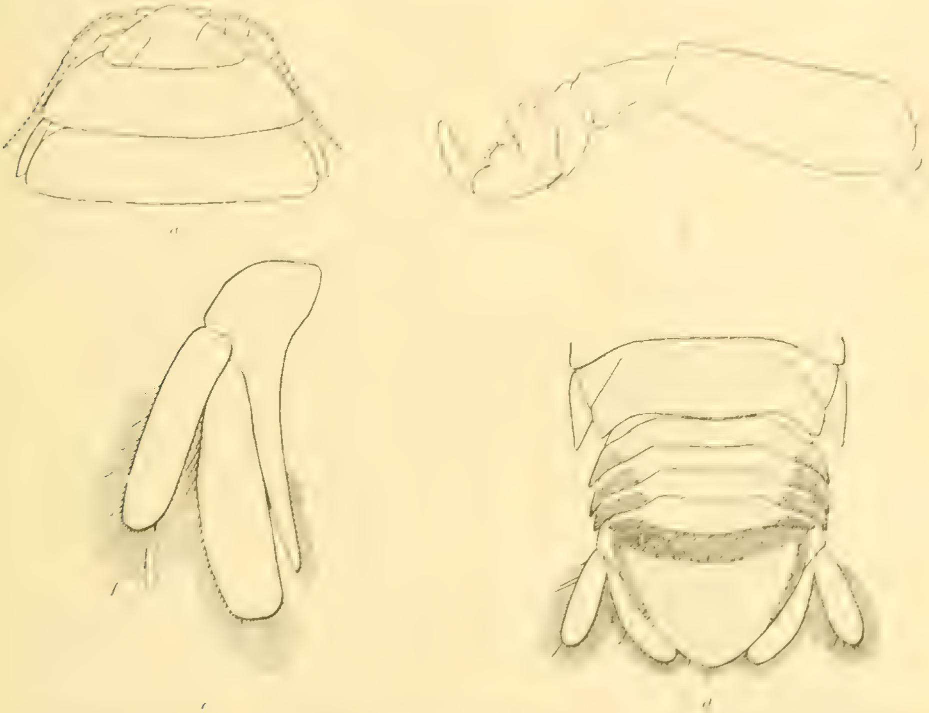


FIG. 2.—*Rocinela belliceps* (Stimpson). *a*, Head and antennæ, × 3½; *b*, leg of third pair, 11½; *c*, uropod, × 8½; *d*, abdomen, × 3½.

**Rocinela belliceps** (Stimpson).

*Æga belliceps* Stimpson, Proc. Acad. Nat. Sci. Phila., XVI, 1864, p. 155.
*Æga alaskensis* Lockington, Proc. Cal. Acad. Sci., VII, 1877, pt. 1, p. 46.
*Rocinela alaskensis* Richardson, Proc. Am. Phil. Soc., XXXVII, 1898, p. 11.
*Rocinela belliceps* Richardson, Proc. U. S. Nat. Museum, XXI, 1899, p. 827.

*Localities.*—Stations 4197 and 4193, Gulf of Georgia, Halibut Bank; station 4200, Queen Charlotte Sound, off Fort Rupert, British Columbia; station 4218, Admiralty Inlet, vicinity of Port Townsend; stations 4233 and 4236, vicinity of Yes Bay, Behm Canal; station 4247, Kasaan Bay, Prince of Wales Island, Southeast Alaska; stations 4269 and 4268, Afognak Bay, Afognak Island, Central Alaska; station 4282, Chignik Bay, Alaska Peninsula. Depth, 14–182 fathoms.

### **Rocinela angustata** Richardson.

*Rocinela laticauda* Richardson (not Hansen), Proc. Am. Philos. Soc., XXXVII, 1898, No. 157, pp. 14–15, figs. 5–6; Proc. U. S. Nat. Museum, XXI, 1899, p. 828.

*Rocinela angustata* Richardson, Proc. U. S. Nat. Museum, XXVII, 1904, p. 33.

*Localities.*—Station 4248, Eastern Passage (vicinity of Stikine River Delta), Southeast Alaska; station 4235, vicinity of Yes Bay, Behm Canal. Depth, 67–181 fathoms.

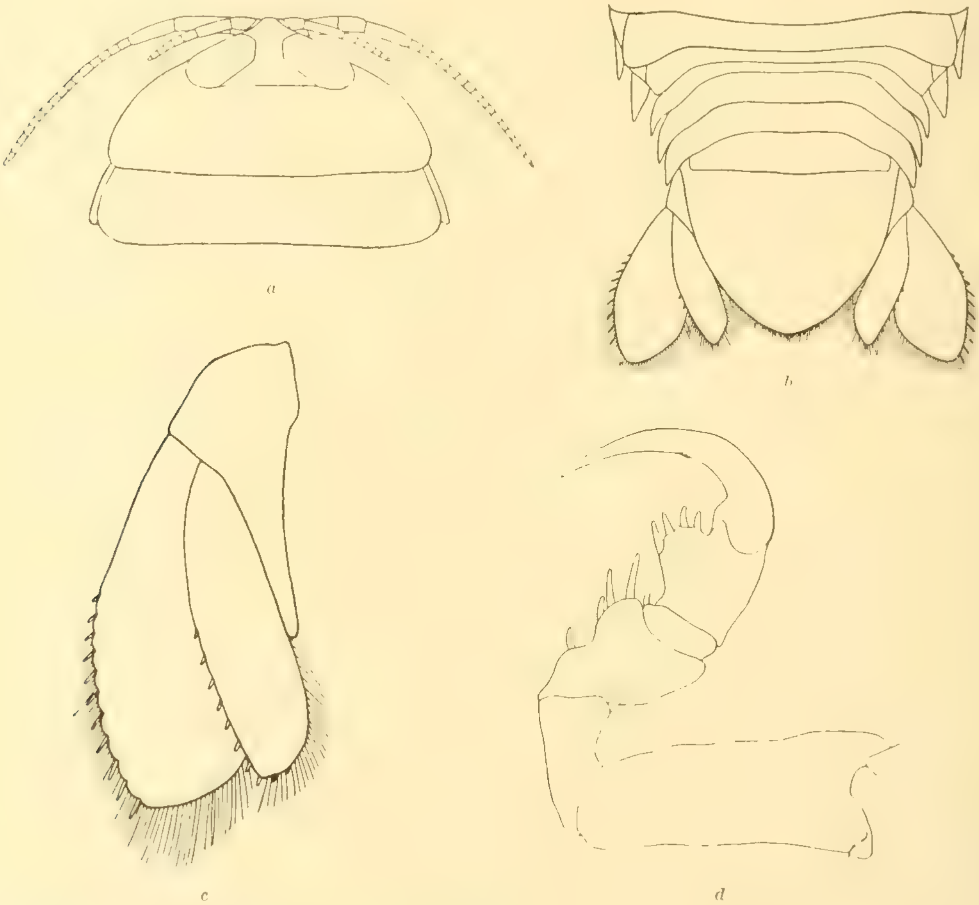


FIG. 3.—*Rocinela angustata* Richardson. *a*, Head with antennæ, × 3; *b*, abdomen with uropoda, × 3; *c*, right uropod, × 8⅔; *d*, leg of third pair, 11¼.

### **Rocinela propodialis** Richardson, new species.

Body nearly twice as long as wide. Color brown, with small black dots.

Head triangular and produced in front in a broad median process. Eyes large and separated in front by a distance equal to the length of one eye. The first pair of antennæ extend to the posterior margin of the head or to the end of the peduncle of the second pair; the flagellum has four to six joints. The second pair of antennæ reach the posterior margin of the second thoracic segment; the flagellum has 16 joints.

The several segments of the thorax are about equal in length, the first segment being a little longer and the last a little shorter than any of the others. The epimera of all the segments are produced at the outer posterior angle, becoming more and more pointed in the last 4 segments. The epimera of the last segment only project beyond the posterior margin of the segment.

The first segment of the abdomen is entirely concealed by the last thoracic segment. The fifth is narrower than the preceding ones, but longer in the median line. The terminal abdominal segment is linguiform, rounded posteriorly, with smooth margins furnished with short hairs.

The uropoda do not exceed in length the terminal abdominal segment. The outer branch is somewhat narrower and is shorter than the inner, and both branches are armed with a few short spines along the outer margins, and with long hairs along the inner margins.

The first three pairs of legs have the propodus armed with a process, the edge of which is denticulate with six teeth meeting squarely and without interval, forming an unbroken line; the carpus is armed with one inconspicuous spine; the merus has five short blunt spines along the inner margin, and the ischium is furnished with one long spine at the outer distal angle. The last four pairs of legs are armed with numerous spines.

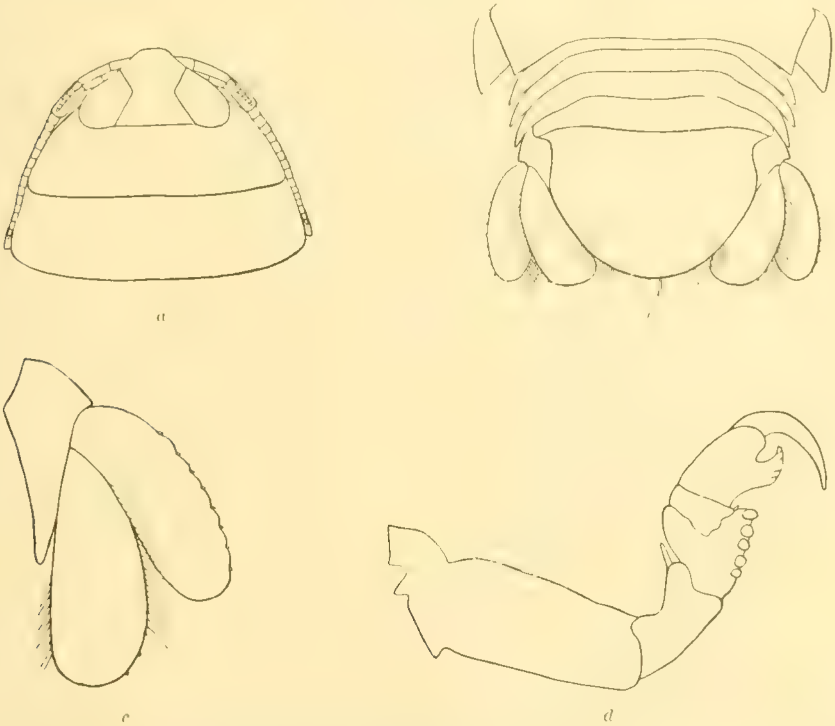


FIG. 4.—*Rocinela propodialis* Richardson, new species. *a*, Head with antennæ, × 3⅓; *b*, abdomen with uropoda, × 3⅓; *c*, right uropod, × 8⅔; *d*, leg of third pair, 11⅓.

Only one specimen, a male, and the type (No. 29248 U. S. Nat. Mus.), was taken by the *Albatross*, at station 4205, Admiralty Inlet, vicinity of Port Townsend, at a depth of 15–26 fathoms.

This species differs from *R. angustata* Richardson *, which it closely resembles, in the denticulate process arming the propodus of the first three pairs of legs, with six contiguous teeth meeting squarely along the edge, while in *R. angustata* the propodus is armed with four long spines; in having the merus of these legs armed with five blunt spines instead of four long ones; in having the outer branch of the uropoda a little shorter and narrower than the inner branch instead of almost twice as wide; and in having the frontal process of the head wider and the distance between the eyes in front greater than in *R. angustata*.

---

*See Proc. U. S. Nat. Mus., Vol. XXVII, 1904, p. 33.

## Family SPHÆROMIDÆ.

### **Sphæroma oregonensis** Dana.

*Sphæroma oregonensis* Dana, U. S. Expl. Exp. Crust. XIV, 1853, II, p. 778, pl. LII, fig. 4; Proc. Acad. Nat. Sci. Phila., VII, 1854, p. 177. Stimpson, Journ. Bos. Soc. Nat. Hist., VI, 1857, p. 69.
*Sphæroma olivacea* Lockington, Proc. Cal. Acad. Sci., VII, 1877, pt. 1, p. 45.
*Sphæroma oregonensis* Richardson, Proc. U. S. Nat. Mus., XXI, 1899, p. 836.

*Locality.*—Not given.

## VALVIFERA OR IDOTEOIDEA.

## Family IDOTEIDÆ.

### **Idotea wosnesenskii** Brandt.

*Idotea wosnesenskii* Brandt, Middendorff's Sibirische Reise, 1851, Zool., II, Cr., p. 146.
*Idotea hirtipes* Dana, Cr., U. S. Expl. Exp., XIV, 1853, pt. 2, p. 704, pl. XLVI, fig. 6.
*Idotea wosnesenskii* Stimpson, Bost. Journ. Nat. Hist., VI, 1857, p. 504.
*Idotea media* (Dana?) S. Bate, in Lord's Naturalist in British Columbia, II, 1866, p. 282.
*Idotea wosnesenskii* S. Bate, in Lord's Naturalist in British Columbia, II, 1866, p. 281. Miers, Journ. Linn. Soc. London, XVI, Zoology, 1883, p. 40. Richardson, Proc. U. S. Nat. Mus., XXI, 1899, p. 846.

*Localities.*—Taylor Bay, Gabriola Island; head of Mink Arm, Boca de Quadra.

### **Idotea resecata** Stimpson.

*Idotea resecata* Stimpson, Bost. Journ. Nat. Hist., VI, 1857, p. 64, pl. XXII, fig. 7; Proc. Bost. Soc. Nat. Hist., 1859, p. 88. Miers, Journ. Linn. Soc. London, XVI, p. 45, 1883. Richardson, Proc. U. S. Nat. Mus., XXI, 1899, p. 844.

*Localities.*—Kilisut Harbor, near Port Townsend; Marrowstone Point, near Port Townsend; Quarantine Dock, Port Townsend; Karta Bay, Southeast Alaska.

### **Idotea ochotensis** Brandt.

*Idotea ochotensis* Brandt, Middendorff's Sibirische Reise, II, 1851, Crust., p. 145, pl. VI, fig. 33. Miers, Journ. Linn. Soc. London, XVI, 1883, p. 32, pl. I, figs. 8–10. Richardson, Proc. U. S. Nat. Mus., XXI, 1899, p. 846.

*Locality.*—Karta Bay, Southeast Alaska.

## ASELLOTA OR ASELLOIDEA.

## Family JANIRIDÆ.

### **Tole holmesi** Richardson, new species.

Body yellow in color, spotted with numerous brown dots.

Head broader than long, with frontal margin almost straight, very slightly produced in the middle. On either side, a little anterior to the middle of the lateral margin, is a process terminating in two spines. The eyes are large, composite, and situated near the lateral margin, about halfway between the posterior and anterior margins of the head. The first pair of antennæ extend to the end of the fourth joint of the peduncle of the second pair; the basal joint of the peduncle is large, dilated; the two following joints are slender; the flagellum consists of twenty joints. The second pair of antennæ are longer than the body. The first three joints are short, with an articulated exopod on the third joint; the fourth and fifth joints are very long, the fourth being slightly longer than the fifth; the flagellum consists of numerous joints.

The posterior portion of the lateral margin of the first segment of the thorax is produced on either side into a triangular process; the epimeron is situated at the anterior portion of the lateral margin and is produced in a triangular process about as long as the posterior one. The antero- as well as the postero- lateral angles of the second and third segments are each produced in a long process, with the bifurcate epimeron situated between them. The anterior portion only of the lateral margin of the fourth segment is produced with the bifurcate epimeron situated at the posterior portion of the segment. The fifth, sixth, and seventh segments have the anterior portion of the lateral margin produced in a process which extends outward and downward and in the last segment is triangularly produced at the posterior extremity, the epimeron in each segment occupying the posterior portion of the segment.

The abdomen is composed of a single segment whose posterior margin has a widely rounded median expansion with an acutely pointed lateral expansion on either side. The uropoda are about equal to the abdomen in length; the outer branch is slightly shorter than the inner; the basal joint is equal in length to the outer branch.

The legs are all furnished with biunguiculate dactyli. The first pair is prehensile, the carpus being very large and armed with spines along the inner margin; the propodus is serrulate along the inner margin of the proximal end.

Two specimens, both females, were taken by the *Albatross* at station 4253, Stephens Passage, Southeast Alaska, and station 4228, vicinity of Naha Bay, Behm Canal, Southeast Alaska. Depth, 41–188 fathoms. Type in the U. S. National Museum, Cat. No. 29249. This species is named for Dr. Samuel J. Holmes, who has done much work on the crustacea of the Pacific coast.

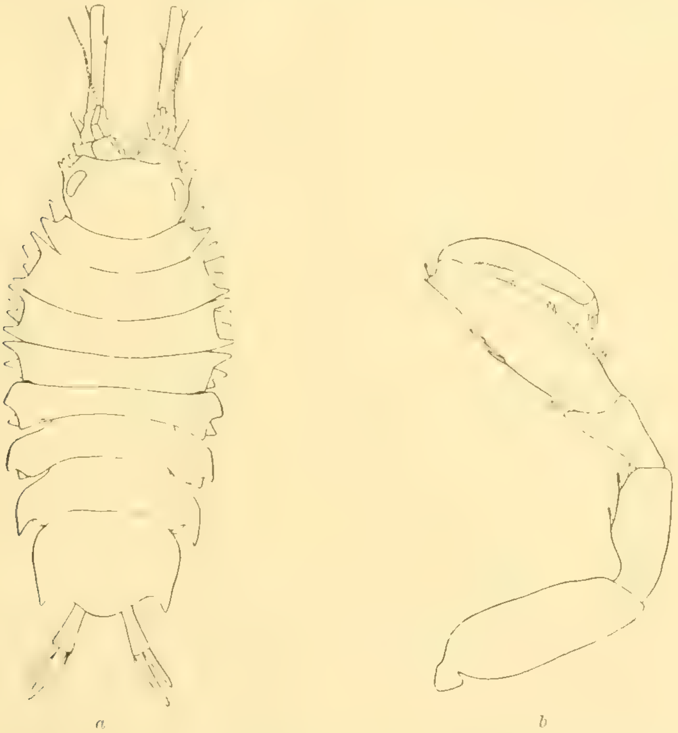


FIG. 5.—*Tole holmesi* Richardson, new species. *a*, General view, × 11¼; *b*, leg of first pair, female, × 33.

## ONISCOIDEA.

### Family ONISCIDÆ.

**Porcellio scaber** Latreille.

*Porcellio scaber* Latreille, Hist. Crust. Ins., VII, p. 45; Gen. Crust., I, p. 70. Budde-Lund, Crust. Isop. Terrestria, 1885, pp. 129–131. (See Budde-Lund for synonymy.)

*Localities.*—Vancouver Island, British Columbia, near Union Wharf, along the shore; Taylor Bay, Gabriola Island, British Columbia, on the shore.

## EPICARIDEA OR BOPYROIDEA.

### Family BOPYRIDÆ.

### **Bopyroides hippolytes** (Krøyer).

*Bopyrus hippolytes* Krøyer, Grønlands Amphipoder, 1838, p. 306 (78), pl. IV, fig. 22; Monog. Fremst. Slægten Hippolytes Nordeske Arter, 1842, p. 262; Voy. en Scand., Crust., 1849, pl. XXVIII, fig. 2. Edwards, Hist. Nat. des Crust., III, 1840, p. 283. Stimpson, Proc. Acad. Nat. Sci. Phila., 1863, p. 140.

*Bopyroides acutimarginatus* Stimpson, Proc. Acad. Nat. Sci. Phila., 1864, p. 156.

*Gyge hippolytes* Miers, Ann. Mag. Nat. Hist. (4), XX, 1877, p. 64 (14). Smith in Harger, Proc. U. S. Nat. Mus., II, 1879, p. 157. Harger, Rep. U. S. Fish Comm., 1880, pt. 6, p. 311. (See Harger for synonymy and bibliography.) Axel Ohlin, Bidrag till Kannedomen om Malakostrak-faunan in Baffin Bay och Smith Sound, 1895, p. 19.

*Bopyroides hippolytes* G. O. Sars, Crust. Norway, II, 1899, pp. 199–200, pl. LXXXIV, fig. 2. Bonnier, Travaux de la Station Zool. de Wimereux, VIII, 1900, pp. 373–375.

*Bopyroides sarsi* Bonnier, op. cit., pp. 376–377

*Bopyroides* sp. Bonnier, op. cit., p. 378.

*Bopyroides* sp. Bonnier, op. cit., p. 378.

*Bopyroides hippolytes* Richardson, Proc. U. S. Nat. Mus., XXIII, 1901, p. 578; Proc. U. S. Nat. Mus., XXVII,1904,. pp. 64-65.

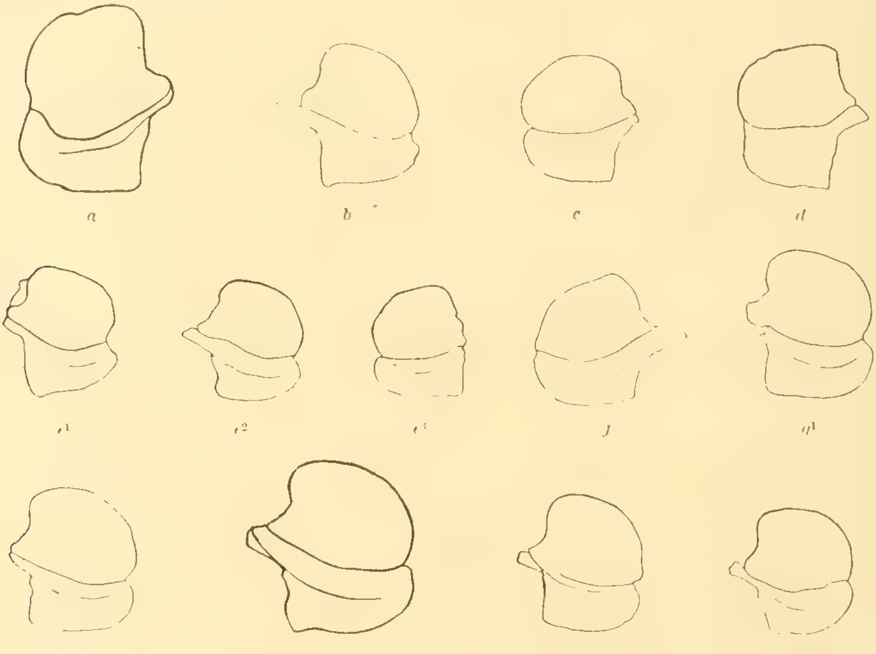


FIG. 6.—First incubatory lamella of *Bopyroides hippolytes*. *a*, Found on *Spirontocaris polaris* from west of Pribilof Islands; 14½. *b*, On *Spirontocaris suckleyi* from station 4222; × 5. *c*, On *Spirontocaris suckleyi* from station 4268; × 11½. *d*, On *Spirontocaris suckleyi* from station 4220; × 11½. *e**, On *Spirontocaris suckleyi* from station 4279. *f*, On *Spirontocaris herdmani* from station 4199; × 31. *g*†, On *Pandalus jordani* from station 4203.

*Localities.*—Station 4192, Gulf of Georgia, off Nanaimo, Vancouver Island, British Columbia; station 4199, Queen Charlotte Sound, off Fort Rupert, Vancouver Island, British Columbia, on *Spirontocaris herdmani* Walker; station 4203, Queen Charlotte Sound, off Fort Rupert, Vancouver Island, British Columbia, on *Pandalus jordani* Rathbun; station 4220, Admiralty Inlet, vicinity of Port Townsend, on *Spirontocaris suckleyi* (Stimpson); station 4222, Admiralty Inlet, vicinity of Port Townsend, on *Spirontocaris suckleyi* (Stimpson); station 4268, Afognak Bay, Afognak Island, Central Alaska, on *Spirontocaris suckleyi* (Stimpson); station 4279, Alitak Bay, Kadiak Island, Central Alaska, on *Spirontocaris suckleyi* (Stimpson).

---

* From three different specimens found on the same species of host and from the same locality. Enlargement, $e^1$, × 7; $e^2$, × 11½; $e^3$, × 7.

† From five different specimens found on the same species of host and from the same locality. Enlargement, $g^1$, × 11½ $g^2$, × 11½; $g^3$, × 11½; $g^4$, × 11½; $g^5$, × 11½.

A number of drawings are presented of the first incubatory lamella and the sixth leg of *Bopyroides hippolytes* (Krøyer), from specimens found on the same and on different hosts, taken from the same and from different localities. The slight variations seen to exist in specimens coming from different hosts is paralleled by variations of a similar nature in specimens coming from the same host. If these variations can not be considered as individual, more marked in this group of isopods than in any other, owing to the parasitic mode of life, there seems to be no other course possible than to make a new species of each individual. As these differences are slight, and as the general form of the parts is about the same, it would probably be better to consider them simply as variations or modifications.

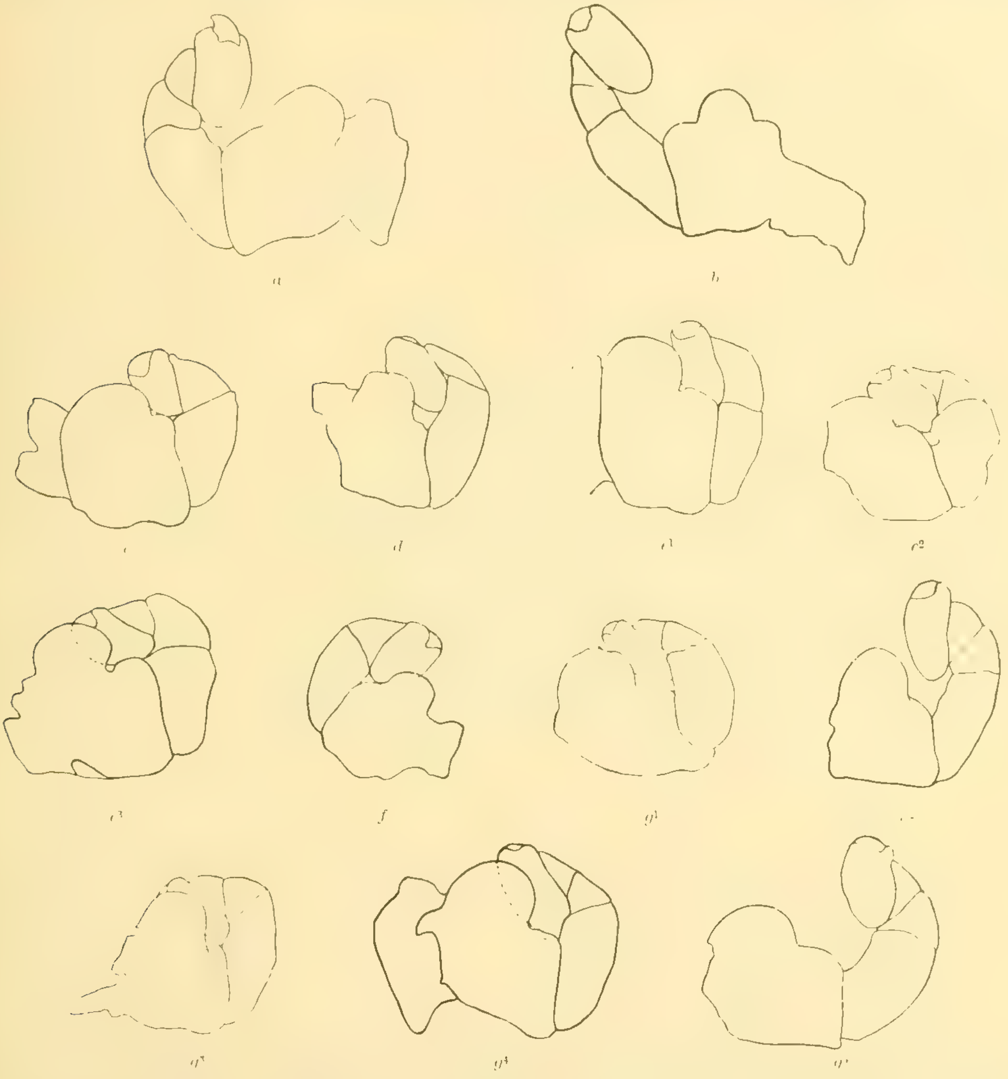


FIG. 7.—Sixth leg of *Bopyroides hippolytes*. *a*, Found on *Spirontocaris polaris** from west of Pribilof Islands; × 52. *b*, On *Spirontocaris suckleyi* from station 4222; × 41. *c*, On *Spirontocaris suckleyi* from station 4268; × 52. *d*, On *Spirontocaris suckleyi* from station 4220; × 52. *e*†, On *Spirontocaris suckleyi* from station 4279. *f*, On *Spirontocaris herdmani* from station 4199; × 77½. *g*‡, On *Pandalus jordani* from station 4203.

---

* The parasite from *S. polaris* has distinct ovarian bosses on the first four segments of the thorax.

† See first note on page 218. Enlargement, $e^1$, × 39; $e^2$, × 52; $e^3$, × 52.

‡ See second note on page 218. Enlargement, $g^1$, × 39; $g^2$, × 52; $g^3$, x 39; $g^4$, × 41; $g^5$, × 52

I hope very soon to be able to extend this investigation to specimens of *Bopyroides hippolytes* from other hosts than those given here and to carry on the same studies with *Argeia pugettensis* and *Phryxus abdominalis.*

### **Argeia pugettensis** Dana.

*Argeia pugettensis* Dana, U. S. Expl. Exp. XIV, 1853, Crust., II, p. 804, pl. LIII, fig 7. Stimpson, Bos. Journ. Nat. Hist., VI, 1857, p. 71.

*Argeia* sp.? Calman, Ann. N. Y. Acad. Sci., XI, No. 13, 1898, p. 281.

*Argeia pugettensis* Richardson, Proc. U. S. Nat. Museum, XXI, 1899, p. 868; XXVII, 1903, pp. 60-64; Proc. U. S. Nat. Museum, XXVII, 1904, pp. 60-64.

*Localities.*—Station 4192, Gulf of Georgia, off Nanaimo, Vancouver Island, British Columbia; Kilisut Harbor, near Port Townsend, on *Crangon alaskensis* Lockington; stations 4220 and 4222, Admiralty Inlet, vicinity of Port Townsend, on *Crangon alaskensis* Lockington and *Crangon communis* Rathbun; station 4227, vicinity of Naha Bay, Behm Canal, Southeast Alaska, on *Crangon communis* Rathbun, and *Nectocrangon dentata* Rathbun; depth, 16–89 fathoms.

### **Phryxus abdominalis** (Krøyer).

*Bopyrus abdominalis* Krøyer, Naturhistorisk Tidsskrift, II, 1840, pp. 102-289, pls. I, II; Monog. Fremst. Slægten Hippolytes nordiske Arter, 1842, p. 263.

*Phryxus hippolytes* Rathke, Fauna Norwegens, 1843, p,, 40, pl. II, figs. 1–10.

*Phryxus abdominalis* Lilljeborg, Œfvers. Kongl. Vet.-Akad. Förh., IX, 1852, p. 11. Steenstrup and Lütken, Vidensk. Meddelelser, 1861, p. 275 (9). Bate and Westwood, Brit. Sessile-eyed Crust., II, 1868, p. 234. Norman, Rep. Brit. Assoc., 1869, p. 288; Proc. Royal Soc. Lon., XXV, 1876, p. 209. Buchholz, Zweite deutsche Nordpolfahrt, 1874, p. 287. Metzger, Nordseefahrt der Pomm., 1875, p. 286. Miers, Ann. Mag. Nat. Hist. (4), XX, 1877, p. 65 (15). Smith in Harger, Proc. U. S. Nat. Museum, II, 1879, p. 158. Harger, Rep. U. S. Fish Comm., 1880, pt. 6. (See Harger for synonymy and bibliography.) Axel Ohlin, Bidrag till Kannedomen om Malakostrakfaunan i Baffin Bay och Smith Sound, 1895, pp. 18–19. Sars, Crust. of Norway, II, 1899, pp. 215–217, pl. XC, XCI. Richardson, Proc. U. S. Nat. Museum, XXIII, 1901, p. 577, and XXVII, 1904, pp. 58–59.

*Localities.*—Station 4192, Gulf of Georgia, off Nanaimo, Vancouver Island, British Columbia, on *Spirontocaris bispinosa* Holmes; station 4216, Admiralty Inlet, vicinity of Port Townsend, on *Spirontocaris tridens* Rathbun; station 4220, Admiralty Inlet, vicinity of Port Townsend, on *Spirontocaris tridens* Rathbun; station 4222, Admiralty Inlet, vicinity of Port Townsend, on *Spirontocaris tridens* Rathbun; station 4229, vicinity of Naha Bay, Behm Canal, Southeast Alaska, on *Spirontocaris macrophthalma* Rathbun; station 4230, vicinity of Naha Bay, Behm Canal, Southeast Alaska, on *Spirontocaris macrophthalma* Rathbun; station 4290, Uyak Bay, Kadiak Island, on *Spirontocaris suckleyi* (Stimpson).

Depth, 16–256 fathoms.

## Family DAJIDÆ.

### **HOLOPHRYXUS Richardson**, new genus.

This genus differs from *Dajus* Krøyer in the absence of all appendages to the abdomen of the female and in lacking all trace of segmentation. It differs from *Notophryxus* Sars and *Aspidophryxus* Sars[a], in having all five pairs of incubatory plates, only one pair being present in Sars' genera; in having no trace of segmentation, in the shape of the oral area, and the position and form of the abdomen, etc. It differs from *Heterophryxus* Sars[b] in the position of the last pair of legs, which in *Heterophryxus* are rather anomalous in structure, are placed at the posterior extremity of the body, and are adapted for clasping. It differs from *Branchiophryxus* Caullery[c] in having five pairs of legs and five pairs of incubatory plates, while in *Branchiophryxus* there are but four pairs of legs and four pairs of incubatory plates. It differs from *Zonophryxus* Richardson[d] in lacking pleopoda, one pair being present in *Zonophryxus*, in the form of the abdomen, and in the general shape of the body. It differs from *Prodajus* Bonnier[e] in the form of the abdomen, which is unsegmented and not bifurcate.

---

[a] Crustacea of Norway, II, 1899, pp. 225–231. Norwegian North-Atlantic Expedition, Crust. I, 1885, pp. 136–139.

[b] Challenger Report, XIII, 1885, Pt. XXXVII, Report on the Schizopoda, pp. 220–221, pl. XXXVIII, figs. 8–14.

[c] Journ. R. Micr. Soc. Lond., 1897, pt. 3, p. 204. Zool. Anzeiger, XX, 1897, pp. 88–92.

[d] U. S. Fish Comm. Report, 1903, pp. 51–52.

[e] C. R. Acad. Sc. Paris, CXXXVI, 1903, pp. 102–103.

### **Holophryxus alaskensis** Richardson, new species.

Body of female irregular in outline. Color uniformly light yellow. Head represented by a bilobed prominence, anterior to squarish body. Eyes wanting. Dorsal surface of thorax with no trace of segmentation; a few lines only are present, representing creases or folds in the integument and having no relation to suture lines. The abdomen projects below the thorax—although there is no distinct boundary between these two divisions of the body—as a triangular process without any trace of segmentation and with no appendages. Uropoda and pleopoda are entirely wanting.

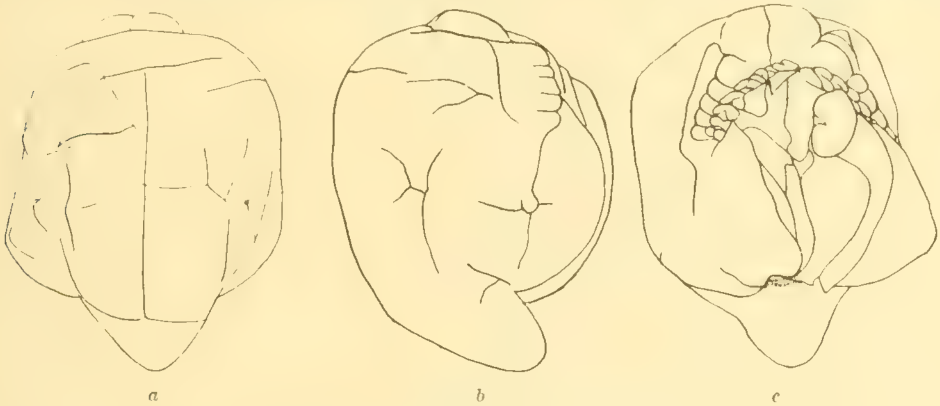


FIG. 8.—Adult female of *Holophryxus alaskensis* Richardson, new species. *a*, Dorsal view, × $4\frac{2}{3}$; *b*, lateral view, × $4\frac{2}{3}$; *c*, ventral view, × $4\frac{2}{3}$.

In a lateral view the first five segments of the thorax are represented by the five coxal plates, which bound the oral area, and are not separated by sutures from the dorsal surface of the body. On the ventral side the oral area is bounded anteriorly by the head and laterally by the two divergent rows of coxal plates. The antennæ and antennulæ are quite rudimentary. The antennæ seem to be composed of three joints, the antennulæ of two. There are five pairs of legs surrounding the oral area, situated just within the two rows of coxal plates. From the bases of these legs five pairs of incubatory plates arise, the last pair overlapping in the middle ventral line.

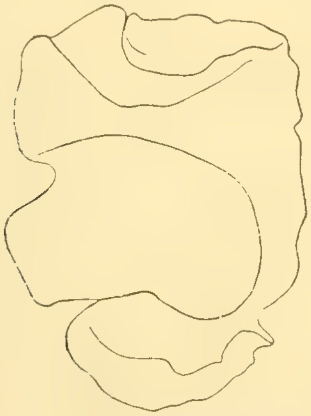


FIG. 9.—Maxilliped, *Holophryxus alaskensis*, × 41.

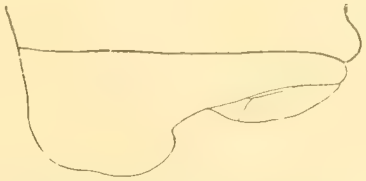


FIG. 10.—Terminal segment of first lamella of incubatory plates, *Holophryxus alaskensis*, 41.

No males were found. Three specimens were taken by the *Albatross* at station 4236, vicinity of Yes Bay, Behm Canal, and station 4257, vicinity of Funter Bay, Lynn Canal. Depth, 147–350 fathoms.

The host is unknown. The type of the species is in the United States National Museum, Cat. No. 29250.

# LIST OF FISHES COLLECTED IN BOULDER COUNTY, COLORADO, WITH DESCRIPTION OF A NEW SPECIES OF LEUCISCUS.

By CHANCEY JUDAY,
*University of Colorado.*

# LIST OF FISHES COLLECTED IN BOULDER COUNTY, COLORADO, WITH DESCRIPTION OF A NEW SPECIES OF LEUCISCUS.

---

By CHANCEY JUDAY.
*University of Colorado.*

---

Boulder County lies in the basin of South Platte River and is drained chiefly by two streams, St. Vrain Creek and Boulder Creek, the latter becoming a tributary of St. Vrain Creek before their waters reach South Platte River. The southern part of the county is drained by Boulder Creek, which receives South, Middle, and North forks in its upper course, these branches having their beginnings in the Arapahoe and James Peak region; and the northern part by St. Vrain Creek, which has three main branches in its upper course, North and South forks and Left Hand Creek, all of which have their sources on the eastern slope of the high mountain country in the western part of the county, on the south side of Longs Peak and in the region south toward Arapahoe Peak.

In September and October, 1903, some fishes were collected from these two streams in their lower courses—that is, some distance below the foothill region in Boulder Creek. The collections were made a few miles east of the city of Boulder; in St. Vrain Creek, in the vicinity of Longmont; also, two species (*Pomoxis sparoides* and *Micropterus salmoides*) were obtained from Culbertson's Lake, a small private lake about 5 miles east of Boulder, into which they have been introduced.

Trout are found in the mountain courses of these streams, but no specimens were obtained. So far as the writer has been able to determine, but a single species, besides a mention of the trout, has been reported from the county before. Jordan states that he found young *Catostomus griseus* in Boulder Creek in the canyon above Boulder.[a] Twenty-five species of fishes are represented in these collections. The trout, of course, are still to be added to the list, and there is no doubt that more extensive collections would result in the addition of still other species.

The writer wishes to acknowledge his indebtedness to Judge Junius Henderson, of Boulder, and Prof. D. W. Spangler, of Longmont, for their valuable assistance in making the collections.

In the following list the letter "B" indicates the species found in Boulder Creek and "V" those found in St. Vrain Creek.

---

[a] Bull. U. S. Fish Com., Vol. IX, pp. 1-36, 1889.

**Carpiodes velifer** (Rafinesque). V.

Only a few specimens were obtained, from a deep pool which was connected with the creek only during flood season.

**Catostomus griseus** (Girard). B, V.

**Catostomus commersonii** (Lacépède). B, V.

**Campostoma anomalum** (Rafinesque). B, V.

**Chrosomus erythrogaster** Rafinesque. B, V.

This species had not previously been noted so far west. Jordan and Evermann (Bull. 47, U. S. Nat. Mus., p. 209) give Iowa as the western limit of its range.

**Hybognathus nuchalis** Agassiz. B, V.

These specimens have a dark lateral band.

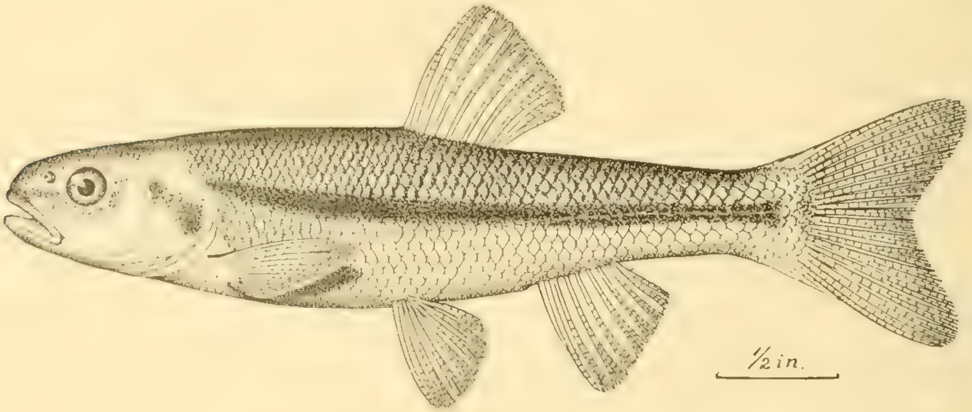
**Pimephales promelas** Rafinesque. V.

Only one specimen obtained.

**Semotilus atromaculatus** (Mitchill). B, V.

**Leuciscus evermanni** Juday, new species.

Among the specimens obtained from Boulder Creek, three were found which belong to the genus *Leuciscus*, but which apparently represent a new species, a description of which is given below. The specimens were not examined until after they had been in preserving fluid for some time, and later efforts to obtain more were unsuccessful; consequently, life colors can not be given. Unfortunately, too, the largest specimen, which was intended for the type, was misplaced before the description was completed and has not since been found, so that the second in size is here described as the type. Some notes on the largest one had been made, however, and these are given in the table. It is a very great pleasure to me to name the species for Dr. Barton Warren Evermann, of the Bureau of Fisheries.



*Leuciscus evermanni* Juday, new species.

Head 3.66 in length; depth 4.6; eye 5 in head; snout 3.1; maxillary 3.1; mandible 2.92; interorbital 2.86; scales 9–47–5, 22 before dorsal; D. 8; longest ray of dorsal 1.33 in head; A. 8; longest anal ray 1.7 in head; pectoral 1.49 and ventral 1.81 in head; teeth 1, 5–5, 2.

Body rather elongate, moderately robust anteriorly, and little compressed; head moderate, subconical, its width just behind eyes 1.4 in its length; snout rather blunt; eye moderate, situated anteriorly and rather high in head; mouth moderate, terminal, oblique, the maxillary barely reaching front of orbit; jaws about equal; upper lip about on level with lower edge of pupil; scales rather large; lateral line decurved; all the fins except the caudal rather small; ventrals barely reaching vent; origin of dorsal midway between tip of snout and base of caudal, over ventrals; least depth of caudal peduncle 2.6 in head.

The general shape is much like that of *Semotilus corporalis* (Mitchill) (Jordan and Evermann, Bulletin 47, p. 221), but the snout is blunter than that of the latter of this size, and is without barbels.

Color in alcohol, back olive, made dusky by the dusky margins of the scales; a black streak along middle of back from occiput to dorsal fin splitting and passing each side, reuniting behind fin and continuing to top of base of caudal; top of head black and snout slate; side of head below level of eye, nearly all of side of body below lateral line, and belly pale; commencing on about the eighth scale behind the upper edge of the opercle and about the middle of the third above and including the lateral line, a narrow black line which becomes more distinct posteriorly, extending backward and curving downward gradually to the lateral line about the twenty-fifth scale, thence running to base of caudal along upper edge of lateral line; anteriorly a dusky shade between the black line and the lateral line, posteriorly this dusky shade more intense, about two scales wide with the black line extending through the middle of it; lower fins pale; dorsal and caudal a little dusky. Length 88 mm. (3.46 inches).

The following table shows the measurements and counts of all three specimens:

| | Length of body. | Head in length | Depth in length | Eye in head. | Snout in head. | Maxillary in head. | Mandible in head. | Interorbital in head. | Dorsal fin. | Longest dorsal ray in head. | Anal fin. | Longest anal ray in head. | Pectoral in head. | Ventral in head. | Teeth. | Scales. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *mm.* | | | | | | | | | | | | | | | |
| Type ... | 88 | 3.66 | 4.6 | 5 | 3.1 | 3.1 | 2.92 | 2.86 | 8 | 1.33 | 8 | 1.7 | 1.49 | 1.81 | 1,5-5,2 | 9-47-5 |
| Cotype No. 1.. | 67 | 3.67 | 4.4 | 4.67 | 3 | 3 | 3 | 3 | 8 | 1.3 | 8 | 1.66 | 1.46 | 1.81 | 1,5-5,1 | 9-45-5 |
| Cotype No. 2.. | 99 | 3.77 | 4.61 | 5.5 | 3.14 | 3.14 | 2.75 | 3.11 | 8 | 1.31 | 8 | 1.69 | 1.57 | 1.83 | 1,5-5,1 | 9-47-5 |

Type, No. 51,841, U. S. National Museum; cotype, No. 1, Museum of University of Colorado.

Type locality, Boulder Creek, Boulder, Colo. Collectors, Juday and Henderson.

**Notropis cayuga** Meek. V.

**Notropis scylla** (Cope). B, V.

**Notropis piptolepis** (Cope). B.

**Notropis lutrensis** (Baird & Girard). V.

**Notropis cornutus** (Mitchill). B, V

**Phenacobius scopifer** (Cope). V.

**Rhinichthys cataractæ dulcis** (Girard). B.

**Hybopsis kentuckiensis** (Rafinesque). B, V.

**Couesius dissimilis** (Girard). B.

**Fundulus zebrinus** Jordan & Gilbert. B, V.

**Fundulus floripinnis** (Cope). B, V.

**Pomoxis sparoides** (Lacépède). Culbertson's Lake.

**Apomotis cyanellus** (Rafinesque). V.

**Micropterus salmoides** (Lacépède). Culbertson's Lake.

**Boleosoma nigrum** (Rafinesque). B, V.

**Etheostoma iowæ** Jordan & Meek. V.

This species has not been previously noted west of Valentine, Nebr. (Jordan and Evermann Bulletin 47, p. 1084.)

# THE FISH FAUNA OF THE TORTUGAS ARCHIPELAGO.

By DAVID STARR JORDAN and JOSEPH C. THOMPSON.

# THE FISH FAUNA OF THE TORTUGAS ARCHIPELAGO.

By DAVID STARR JORDAN and JOSEPH C. THOMPSON.

The Tortugas Archipelago consists of a group of seven small, sandy islands and a large reef plateau so situated as partially to form a lagoon of about 50 square miles. Two of the islands are inhabited. On Garden Key is Fort Jefferson, now converted into a United States naval station, and on Loggerhead Key is a light-house. Pure deep ocean water surrounds the islands, and there are none of the extensive mud flats and mangrove-covered shores so characteristic of the keys along the main land of Florida.

The northern edge of the Gulf Stream lies from 25 to 30 miles south of the Tortugas, but a strong southerly breeze is sufficient to drive the surface waters, unaccompanied by the current, upon the islands, and under these conditions quantities of gulf weed are cast upon the shores. Vast numbers of floating animals also are borne along upon the surface of the Gulf Stream, drawn into it by winds and currents from the adjacent tropical regions of the Atlantic, and thus pelagic fish from all over the Gulf of Mexico and West Indies may be drifted past the Tortugas. The temperature of the surface waters in the immediate vicinity is remarkably high, being about 74 to 77° F. in winter and 80 to 86° F. in summer, the average for the whole year being about 78° F.

About ten square miles of shallow reef flats surround the islands, and these support a fauna which, according to Dr. A. G. Mayer, for variety and abundance, appears to be unsurpassed by that of any locality on the Atlantic coast of the United States. At present 218 species of fishes are known to occur at the Tortugas. All of these have been taken in reef collecting or at moderate depths with the line. When a thorough investigation can be made in the region, a very great number of additional forms will doubtless be found. Heretofore Tortugas was the type locality for 6 species; the last year's collecting has increased this number to 14, the following new species having been discovered by Dr. Thompson: *Holocentrus tortugæ*, *Eriota personata*, *Rhinogobius tortugæ*, *Gnatholepis thompsoni*, *Elacatinus oceanops*, *Ericteis kalisheræ*, *Excestides egregius*, *Gnathypops aurifrons*.

This paper is based on a collection made by the junior author while on duty as surgeon at the United States Naval Station on Garden Key. Duplicate series have been sent to the United States National Museum, to the United States Bureau of Fisheries, and to the Museum of Stanford University. Several species of interest have been treated in a previous paper, sent to press before the receipt of the full collection. Field notes by Dr. Thompson in the present article are signed "T."

## Family GINGLYMOSTOMIDÆ.

1. **Ginglymostoma cirratum** (Gmelin).

This shark may be observed daily almost anywhere about the islands, though it is reported by the local fishermen to come in greatest numbers in the fall. Individuals are often seen burrowing under a coral mass in search of fish and crustaceans, so busily engaged that they can be approached and struck with an oar without being disturbed. A small one, 21.25 inches long, was caught by the tail when thus occupied; while being carried to the laboratory in a bucket it devoured four specimens of *Acteis moorei*. (T.)

## Family CARCHARIIDÆ.

2. **Carcharias lamia** (Rafinesque).

Reported from the Tortugas by Dr. J. A. Henshall.

3. **Scoliodon terræ-novæ** (Richardson).

A fœtal specimen in the collection of Dr. Thompson.

## Family SPHYRNIDÆ.

4. **Sphyrna tiburo** (Linnæus).

This species can be taken throughout the year with the hook and line. It very frequently follows fishing boats, attracted by the bait, and will snap from the line fish that have been hooked.

5. **Sphyrna zygæna** (Linnæus).

Occasionally caught by the local fishermen; none taken by Dr. Thompson.

## Family MYLIOBATIDÆ.

6. **Stoasodon narinari** (Euphrasen).

Observed by Dr. Thompson. These fishes often travel in pairs, swimming a few feet below the surface in a long, straight course.

## Family MOBULIDÆ.

7. **Manta birostris** Walbaum.

Reported by fishermen.

## Family ELOPIDÆ.

8. **Tarpon atlanticus** (Cuvier & Valenciennes).

Every season a few tarpons are taken in the main channel southeast of Garden Key. None very large. (T.)

9. **Elops saurus** Linnæus.

One specimen about 1 inch long taken in a seine along the southwest shore of Garden Key in eel grass and in 3 feet of water. Adult fish have not been taken by the fishermen in the immediate vicinity. (T.)

## Family ALBULIDÆ.

10. **Albula vulpes** (Linnæus).

Fish of this species are caught by almost every fishing party. None over 18 inches long was seen. The fish apparently do not come into shoal water, 3 fathoms being the shallowest in which they were taken. (T.)

## Family DUSSUMIERIIDÆ.

11. **Jenkinsia stolifera** (Jordan & Gilbert).

A number were taken in January on the shoal to the west of Garden Key, in about a fathom of water, their length ranging from 1.73 to 1.87 inches. Two specimens in the collection. (T.)

### Family CLUPEIDÆ.

12. **Harengula sardina**[a] (Poey).

Very abundant at times. (T.)

13. **Harengula macrophthalma** (Ranzani).

On October 1, 1902, an enormous school of this species was seen along the northern moat wall of Garden Key. The only specimen saved is now deposited in the reserve series of the Bureau of Fisheries. (T.)

14. **Harengula humeralis** (Cuvier & Valenciennes).

This is the commonest species of sardine at the Tortugas, and is caught by the local fishermen for live bait. (T.)

### Family ENGRAULIDÆ.

15. **Anchovia perfasciata** (Poey).

A few specimens taken in January, 1902, in 6 fathoms of water in the west channel, and during the same week a few under coral heads in a fathom of water near the west shore to the west of Garden Key. (T.)

16. **Anchovia brownii** (Gmelin).

A few specimens found in the moat at Garden Key in September, 1902. (T.)

### Family SYNODONTIDÆ.

17. **Synodus fœtens** (Linnæus).

These fish, when resting on the bottom, lie with the head and shoulder girdle well elevated, then suddenly by a curious rocking and groveling motion settle down until only the top of the head is visible. When frightened they dart off a few yards, then settle down again by a repetition of this peculiar motion. Two specimens were seen, and one, 10 inches long, was taken in a cast net. It was deposited in the Brooklyn Institute of Arts and Sciences. (T.)

18. **Trachinocephalus myops** (Forster).

Reported by Dr. Bean from Garden Key in 1883.

### Family MYRIDÆ.

19. **Ahlia egmontis** (Jordan).

One specimen taken among the eel grass on the flat southwest of Garden Key in 3 feet of water. It was swimming a few inches from the bottom, slowly worming its way among the blades. The life color is a uniform yellow orange, except on the abdomen, which is silver. This specimen was deposited in the reserve series of the Bureau of Fisheries. Two other specimens are known, the type, taken at Egmont Key, and one in the collection of H. Maxwell Lefroy, from Bridgetown, Barbados, West Indies, described by Barton A. Bean (Proc. U. S. N. M., vol. 26, 1903). (T.)

### Family OPHICHTHYIDÆ.

20. **Myrichthys acuminatus** (Gronow).

One specimen taken on a solid coral bottom on the east shore of Garden Key in about 18 inches of water. Body of brownish yellow, head and tail being a little lighter; spots on body cream colored, many with yellow centers; spots on head yellow, the more forward ones somewhat deeper; abdomen white; ventral surface of tail cream colored; tip of tail brick-red; nasal tube white; iris canary yellow, orange spot before and behind pupil; pectoral with an orange spot on posterior surface. (T.)

---

[a] The generic name *Sardinella* Cuvier & Valenciennes seems to have been intended for a true sardine, the group later called *Sardinia* by Poey.

## Family MURÆNIDÆ.

21. **Gymnothorax moringa** (Cuvier).

This species lives under coral heads and in rock piles. It is usually seen with the anterior third of the body protruding from the crevice. When fearing attack it will open its mouth in the most threatening manner, draw back a little, and assume a very hostile attitude. If thrust through the body with a spear, it almost invariably escapes by tearing away. The large fish are capable of inflicting a very painful wound, and sometimes attack human beings. About a dozen specimens were seen during the season, none over 4 feet long. (T.)

22. **Gymnothorax funebris** (Ranzani).

This fish is not quite so common as the preceding species. One was taken in the vicinity of Bush Key among the small shallow tide pools. (T.)

## Family BELONIDÆ.

23. **Tylosurus raphidoma** (Ranzani).

On a calm day a few of these fish may be seen basking on the surface, usually quite motionless. They prey upon sardines, which they capture by darting into a school and frightening them. After catching one they manipulate it very ingeniously with their jaws until it is pointed "head on" toward the throat before any endeavor is made to swallow it. They are themselves ruthlessly hunted by the barracuda, which sometimes bites its victim in two and swallows one half, leaving the other portion, which is actively wriggling about, to be devoured by another barracuda. (T.)

## Family HEMIRAMPHIDÆ.

24. **Hemiramphus brasiliensis** (Linnæus).

Only two specimens were seen in this region. They were about 14 inches long and were caught west of Bird Key with hook and line. In the vicinity of the light-house on Rebecca Shoals this species is to be seen by the hundreds, and can be easily caught with a little piece of dough for bait. Over 50 per cent of the fish have a parasitic crustacean attached to the tongue, which the local fishermen claim causes death in time by completely filling the mouth cavity. (T.)

25. **Hyporhamphus unifasciatus** (Ranzani).

Reported by Dr. Henshall in 1889.

## Family EXOCŒTIDÆ.

26. **Parexocœtus orbignianus** (Cuvier & Valenciennes).

On February 7, 1902, a very large mass of sargassum weed drifted into the neighborhood of Tortugas from the edges of the Gulf Stream, the result of a strong southerly gale which had been blowing for the previous two days. This weed brought with it nearly a dozen species of fishes not hitherto taken, among them 9 specimens of *Parexocœtus orbignianus* ranging from 0.47 to 1.33 inches. When of this size the fish is unable to fly, but is capable of leaping a few inches out of the water. It almost invariably jumps out of a net spread beneath it. It may be readily caught with the hand from above, however. (T.)

It is doubtful whether this is the *Exocœtus mesogaster* of Bloch; we may therefore take the name next in date.

27. **Cypselurus furcatus** (Le Sueur).

A number of very young individuals, each with two black barbels at the chin.

## Family AULOSTOMIDÆ.

28. **Aulostomus chinensis** (Linnæus).

Recorded by Porter and Moore from Fort Jefferson; not seen by Dr. Thompson.

## Family FISTULARIIDÆ.

**29. Fistularia serrata** Cuvier.

One specimen 6.13 inches long taken in a seine inside of Long Key. Another that had lost its caudal filament was seen basking among sargassum weed; it escaped capture. (T.)

## Family SYNGNATHIDÆ.

**30. Syngnathus elucens** Poey.

Many specimens from Garden Key.

**31. Syngnathus mackayi** Swain & Meek.

Many specimens from Garden Key.

**32. Syngnathus brachycephalus** Poey.

A few specimens, apparently of this species, in eel grass. Brown, yellow-brown below; body and tail with conspicuous gray bands, between those on dorsum and on side 3 to 4 diamond-shaped patches, gray outlined; head lighter than body, cheeks almost yellow-ochre with conspicuous gray lines, iris yellow; forehead and top of head quite gray; side of snout brown; yellow-brown on abdomen rings, sutures gray, caudal pale edged; entire body, head, and tail much mottled with fine gray specks and blotches, these denser on back. New to the United States fauna. (T.)

**33. Syngnathus scovelli** (Evermann & Kendall).

Collected in 1889 by Dr. Henshall.

**34. Corythroichthys albirostris** (Heckel).

Two specimens.

**35. Corythroichthys cayorum** Evermann & Kendall.

Recorded by Dr. Thompson.

**36. Hippocampus hudsonius** De Kay.

The only specimen was a dried one washed ashore on Middle Key. Rings 11+34. (T.)

**37. Hippocampus stylifer** Jordan & Gilbert.

One specimen 1.33 inches long taken with a seine in the eel grass on the shoal southwest of the West Channel.. Several others sent in the later collection. (T.)

**38. Hippocampus punctulatus** Guichenot.

A single specimen 1.19 inches long taken in a seine inside of the west end of Bush Key. (T.)

## Family ATHERINIDÆ.

**39. Atherina laticeps** (Poey).

This species can be taken any day in the year in moderate numbers in the shoal water about these islands. (T.) It is probably identical with *Atherina stipes*, which species was reported by Garman in 1896.

## Family MUGILIDÆ.

**40. Mugil curema** Cuvier & Valenciennes.

A few individuals taken in the cast net along the north beach of Bird Key. (T.)

**41. Mugil cephalus** (Linnæus).

Fairly common in the winter months, at times congregating in uncountable numbers on the shoal north of Garden Key, where they spend hours swimming around in a huge vortex. This movement is sometimes interrupted by sharks or barracudas, when portions of the school will become detached and form separate gyrating masses. (T.)

**42. Querimana gyrans** (Jordan & Gilbert).

Several small schools were seen in February, swimming at the surface, very close to the stone jetties on the southern side of Garden Key. (T.) It is not certain, however, that these little fish are not the young of *Mugil*.

## Family SPHYRÆNIDÆ.

**43. Sphyræna barracuda** (Walbaum).

Specimens have been taken ranging from 1.5 inches long to more than 5 feet. The large fish can be seen almost any calm day in the shoal water inside of Bush Key. They rarely, if ever, take the hook, but can be captured easily by approaching them quietly in a boat and using a harpoon. The meat is not good, being coarse and very tough. (T.)

## Family HOLOCENTRIDÆ.

**44. Holocentrus ascensionis** (Osbeck).

This species has been reported from the Tortugas by other collectors, and is well known to local fishermen, but none was seen by Dr. Thompson.

**45. Holocentrus siccifer** (Cope).

Heretofore known only by one specimen taken in the Bahamas. The species lives in the most secluded crevices and nooks at the base of coral heads. The only way that it can be captured, apparently, is by the use of dynamite. Several specimens taken. (T.)

This species may be the same as *H. vexillarius* Poey, but the latter is said to have a slenderer form and somewhat different coloration. In *H. siccifer* the membrane of the dorsal fin is dusky, with paler spots above and below, the membranes of the first three spines usually nearly black, axil with a black spot.

**46. Holocentrus tortugæ** Jordan & Thompson, new species. Figure 1.

Head 3.30 in length to base of caudal; depth 3.5 (4.10 to tip of caudal); eye 2.75 in head; maxillary 2.20 in head; D. XI, 13; A. IV, 8; scales 4-42-7. Fourth dorsal spine 2.05 in head; soft dorsal rays 2 in head; third anal spine 2.10; caudal lobes 1.50 in head; pectoral 1.55; ventrals 1.50.

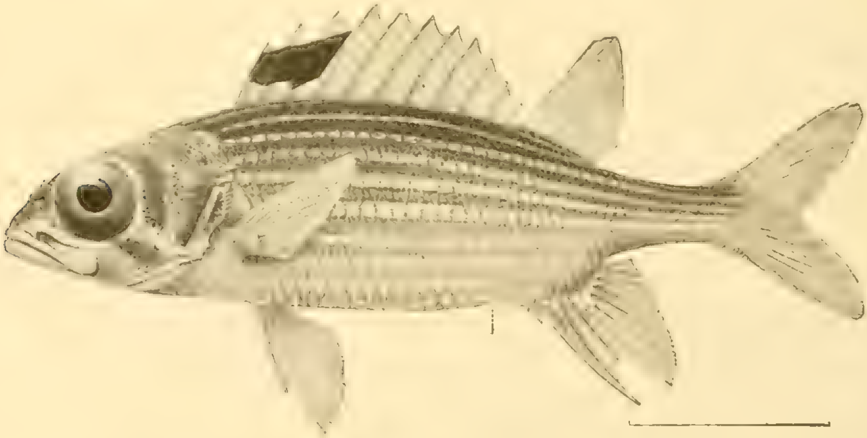


FIG. 1.—*Holocentrus tortugæ* Jordan & Thompson, new species. Type.

Body elliptical-elongate, more slender than in any other West Indian species, the dorsal outline very even; head rather pointed; mouth small, the jaws subequal, the maxillary extending a little past middle of eye; eye very large; preorbital serrated, and with a small spine anteriorly; preopercular spine short, 3 in eye; opercular spines moderate, the upper small and close appressed to the second, which is rather long, the third shorter and slenderer; dorsal spines rather high; soft dorsal elevated; caudal lobes equal; third anal spine much longer than fourth, not reaching near the end of the long and slender caudal peduncle; pectorals moderate; scales rather small, moderately rough.

Color in spirits, grayish, silvery below, the snout, head, and upper parts much dotted with black; a silvery streak along each row of scales, this narrower and more distinct above, 10 such streaks evident; a dark streak downward and backward from eye, with a pale streak above and below it; fins all pale except a jet black, elongate area occupying membranes of first, second, and third spines, ceasing abruptly at fourth spine.

One specimen, 4.2 inches long (No. 8412, Museum Stanford University), was taken by Dr. Thompson on the reef at Garden Key. The only species similarly colored is *H. riparius* Poey, said to have a depth 3.5 times in the total length.

### Family SCOMBRIDÆ.

47. **Scomberomorus maculatus** (Mitchill).

Taken at Garden Key.

48. **Scomberomorus cavalla** (Cuvier).

Often taken by trolling in the deep water southeast of Loggerhead Key.

### Family CARANGIDÆ.

49. **Oligoplites saurus** (Bloch & Schneider).

Taken at Garden Key by Whitehurst and Baker.

50. **Seriola lalandi** Cuvier & Valenciennes.

Reported by fishermen.

51. **Seriola dumerili** Cuvier & Valenciennes.

Reported by fishermen; very young examples in Dr. Thompson's collection.

52. **Seriola fasciata** (Bloch).

Young examples in collection.

53. **Elagatis bipinnulatus** (Quoy & Gaimard).

Reported by fishermen.

54. **Decapterus punctatus** (Agassiz).

Taken with dynamite.

55. **Caranx hippos** (Linnæus).

Recorded by Dr. Thompson.

56. **Caranx chrysos** (Mitchill).

Bird Key.

57. **Caranx latus** Agassiz.

Reported by Professor Nutting from the Tortugas.

58. **Caranx bartholomæi** Cuvier & Valenciennes.

One specimen seen among coral heads, southwest shoal. (T.)

59. **Alectis ciliaris** (Bloch).

Recorded by Porter & Moore from Fort Jefferson.

60. **Selene vomer** (Linnæus).

Young taken on north shore of the Tortugas.

61. **Chloroscombrus chrysurus** (Linnæus).

Taken by Whitehurst in 1883.

62. **Trachinotus palometa** Regan. (*Chætodon glaucus* Bloch, not *Scomber glaucus* Linnæus, also a *Trachinotus.*)

West shore of Tortugas; a specimen 15.13 inches long.

63. **Trachinotus falcatus** (Linnæus).

Specimen sent by Dr. Thompson.

**64. Trachinotus goodei** Jordan & Evermann.

South beach of Tortugas.

**65. Trachinotus carolinus** (Linnæus).

Rather common. Individuals 0.75 of an inch long or less are of a deep coppery brown, the dorsal and anal deep orange red; the color changes suddenly to light gray when the fish is frightened. When the coppery color comes back it appears in blotches, on the upper parts first.

## Family STROMATEIDÆ.

**66. Gobiomorus gronovii** (Gmelin).

These fish appear in midwinter and are to be found until early spring. In 1903 the first one seen was on January 18 in deep water west of East Key. From one to half a dozen specimens, occasionally more, may be found taking refuge under the tentacles of a Portuguese man-of-war. When the host is stranded on the beach they do not abandon it until the last comber lands it high and dry, then they hasten off in search of shelter, orienting themselves under twigs, grass, etc., for an instant, but soon finding their error and searching for another jelly-fish. (T.)

**67. Psenes cyanophrys** Cuvier & Valenciennes.

Length 2.63 inches. Color greenish bronze, dark above; above and below lateral line several lines formed of more or less coalesced dots parallel to dorsal curve; below lateral line many similarly formed horizontal lines; snout yellowish green; dorsal, anal, and ventral dark; pectoral yellowish tinged; caudal of body color. Body at times with many large irregular dark blotches. (T.)

Another specimen of *Psenes* 1 inch long shows the following characters: Color: Body yellowish gray-green, with large irregular blotches on back, arranged as follows: First, anterior to spinous dorsal; second, below last two-thirds of spinous dorsal; third, small and round, below origin of soft dorsal; ourth, largest, below second quarter of soft dorsal; fifth, a round spot below middle of soft dorsal; sixth, like fourth, below posterior part of soft dorsal; seventh, a round spot on side of body at origin of caudal peduncle. At base of caudal peduncle a wide band; extreme tip pale, body colored, spots here light olive green; below eye, cheek, and lower part of body many finely speckled minute brown dots; spinous dorsal dark, like blotches; soft dorsal pale like body color, with blotches at base which are extensions of adjacent body blotches; caudal very pale, with the merest trace of a blotch on each fork; pectorals colorless; ventral webs the color of blotches, rays pale; anal like soft dorsal; iris body-colored, a blotch above and below pupil; snout yellower than head. On body posterior to and below pectoral a large blotch; a small round one posterior to this and below the fifth on back; two spots above anal, posterior one contiguous to sixth dorsal blotch. (T.)

## Family CORYPHÆNIDÆ.

**68. Coryphæna hippurus** Linnæus.

The very young have the dorsal fin inserted behind the head. The color is as follows: Top of head carmine gray; body above black, with pink-gray stripes; body below sooty black; dorsal pink-gray, with bands corresponding to body bands; pectoral a faint yellowish, hyaline; ventral dark yellow margined; anal dark; outer angles of lobes of caudal hyaline, base and center with pigment, upper third pinkish, lower part like body; gills and chest with a golden green sheen. This example vomited a shrimp.

On the afternoon of February 7, 1903, a dozen specimens were taken in the sargassum weed, after a south wind which prevailed for two days. The next morning only one specimen was found, and that early; all the weed had remained in place, but the edge of the mass was frequently visited by schools of snappers, jacks, and needle-fish, which probably devoured all stragglers. (T.)

## Family PEMPHERIDÆ.

**69. Pempheris mulleri** Poey.

These are probably nocturnal, and hide very carefully. Two specimens were obtained by the use of dynamite on Loggerhead Shoal, northwest of light-house, 100 yards from shore, among coral heads at a depth of one fathom.

Color in life of a specimen 5.13 inches long, almost uniform coppery bronze; a dark area along base of anal; dorsal darker than body; dorsal and ventral without spots, a few little smoky blotches on each web. (T.) Species not previously recorded from the United States.

### Family APOGONICHTHYIDÆ.

**70. Amia americana** (Castelnau.)

Color plain red with black dots, in life, with a pinkish silvery sheen, each scale with a gray spot, microscopically composed of fine radiating lines, between these spots black dots with a bright red spot; top of head with a silvery green sheen, snout very dusky; pectoral pinkish; ventral white; anal pinkish, scales at base a trifle pink; caudal with body pink, upper and lower margin black, rays spotted; second dorsal with some rays spotted; first dorsal spines much darker and with spotted webs; spot at base of caudal 0.83 inch in diameter, solid color; an oblong spot on opercle from lower and posterior border of eye to gill-margin, not quite as wide as pupil at beginning, wider below, sides straight. Belly white, lower jaw dark like snout, nape profusely speckled. (T.)

**71. Amia sellicauda** (Evermann & Marsh).

Many specimens, agreeing closely with the original description, except that in the latter the bilobed caudal fin is figured as truncate. Color in life, red; a blackish blotch at base of second dorsal; a blackish saddle on caudal peduncle; blackish mark on opercle, also a golden tinge; rays of all fins a darker red than body; iris black; minute black dots about orbit and snout. In some specimens there is a blackish line at the base of the second dorsal, where the fin joins the body; tip of anal sooty; caudal sooty rimmed. (T.) New to the fauna of the United States.

**72. Mionorus puncticulatus** (Poey.)

One example. Scales in lateral line 26. It is probable that *Apogonichthys alutus* is identical with this species.

Color, very light pink with a strong silvery sheen; an area of minute black dots below eye and another behind it. Dots most numerous above lateral line, and densest forward. Length 1.5 inches. Taken in West Channel, with dynamite, at depth of 35 feet. (T.)

Of the genera related to *Amia* Gronow (=*Apogon* Lacépède), but differing in having both limbs of the preopercle entire, *Apogonichthys-Fowleria* (*auritus*) is distinguished by the absence of palatine teeth, *Foa* Jordan and Evermann (*brachygramma*) by its incomplete lateral line, and *Mionorus* (*lunatus*) by having palatine teeth, and the lateral line complete.

### Family OXYLABRACIDÆ.

**73. Oxylabrax undecimalis** (Bloch).

Two specimens taken. The genus *Centropomus* of Lacépède was based originally on *Perca lucioperca* of Europe.

### Family SERRANIDÆ.

**74. Cephalopholis fulvus** (Linnæus).

Recorded by Garman; not seen by Dr. Thompson.

**75. Cephalopholis cruentatus** (Lacépède).

Recorded by Dr. Henshall, 1889, from the Tortugas.

**76. Epinephelus adscensionis** (Osbeck).

Seen swimming slowly in and out of rock crevices; observed for two weeks, probably the same individual.

Spinous dorsal dusky over greater part, this coextensive with much paler blue area on body; maxillary and lower lip dusky; snout below nostril and cheek below eye deeper blue than rest of body; pectoral hyaline, rays dusky; ventral, anal, and caudal dusky; abdomen grayish blue, shading and evanescent; nape gray-blue at times; tip of caudal peduncle darkest. (T.)

**77. Epinephelus maculosus** (Cuvier & Valenciennes).

Loggerhead Shoals, west of light-house. (T.)

78. **Epinephelus striatus** Bloch.

Common.

79. **Epinephelus morio** (Cuvier & Valenciennes).

Hospital Key.

80. **Promicrops guttata** (Linnæus).

One example, 7 feet 6 inches long.

81. **Mycteroperca venenosa apua** (Bloch).

Reported by Dr. Henshall from Garden Key.

82. **Hypoplectrus unicolor** (Walbaum).

Specimen 3.69 inches long; color, black-brown on top of head, back and spinous dorsal, shading below mid-line to a dark chrome yellow. On area swept by pectoral the scales have each a conspicuous light-gray spot; caudal peduncle with a dark-brown saddle; soft dorsal yellow, with submarginal dusky band; each web with 4 to 6 blue bands; caudal lighter below than body, blue dots on webs; a yellow-margined band of light gray-blue; ventral yellow, with dusky-blue margins; pectoral with plain yellow rays, web quite clear; upper limb of gill-slit with a blue spot; iris brown, with yellow margin, without the slightest trace of blue cross lines.

Specimen 4.33 inches long; much browner, body stripes not conspicuous.

Specimen 3.87 inches long; light olive brown; dorsal, caudal, pectoral, and anal transparent and of yellowish tinge; a pale blue blotch on body between bases of first, second, and third spines of dorsal; two pale streaks across body from below soft dorsal; pale blotch across anterior half of caudal peduncle; pale blotch anterior to pectoral; ventral gray-green above, green below; anterior margin bright blue; on body about 18 azure blue or brown vertical lines, on borders of light areas these lines very pale blue; upper lip with a median and a lateral dot, these coalescing; snout with 9 blue dots hanging over eye in a blue mark ʕ; margin of preopercle blue; posterior to this on opercle another but broader and paler line, which begins on nape; 3 interrupted lines anterior to vertical of first spine of dorsal; caudal very yellow with reddish tinge at tips, dorsal yellow, dusky anteriorly, 6 or 7 faint blue squares on each web, these placed so that when fin is erect they appear as continuations of the lines on body; ventral plain dusky yellow, with dusky border; pectoral pinkish yellow. The darkest part of the fish is a brown spot at upper posterior part of caudal peduncle; each scale in brown area with faint blue central spot; each scale in blue area, with a very pale spot; all profusely speckled with black. (T.)

83. **Hypoplectrus unicolor nigricans** (Poey).

Color in life, warm brown, with a light band across body behind the pectoral, starting on dorsal between first and second spines, widest below middle line; two starting below soft dorsal, joined by a bar where lateral line crosses; one across beginning of caudal peduncle, dumbbell-shaped; dorsal brown; soft dorsal lighter; caudal very light; ventrals black; iris yellow; two black spots on end of caudal peduncle.

Found under a coral head, inside Bush Key, at a depth of 3 feet. (T.)

84. **Hypoplectrus gemma** Goode & Bean.

Described from Garden Key, probably the same as *H. unicolor*.

85. **Diplectrum formosum** (Linnæus).

Color, gray, lighter below; a blue line from head to base of first dorsal spine, along base of dorsal, one from head level with top of eye, horizontally back to middle of soft dorsal; one from back of eye through upper extremity of gill-slit to beginning of caudal peduncle, where it meets its fellow and is continued on back of peduncle; one from above angle of gill to tail; below these a dark line, obscure, ending in a marked blotch at base of tail; below this three more, one-eighth inch apart, between them yellow stripes, wider than the blue; head with three transverse blue lines; one back of eye, there joining the body line passing through the upper end of gill-slit; two between eyes, one level with anterior margin of pupil; tip of lip and snout dusky; four blue lines on cheek, one horizontal and ending with a bifurcation; second extending from angle of opercle forward to a level past rim of eye;

third, wavy; fourth, straight; pectoral, colorless; ventral and anal yellow tinged; dorsal yellow, with two blue bands; caudal blue, upper tip yellow, lower tip dusky; round and oval spots on web. (T.)

86. **Rypticus saponaceus** (Bloch & Schneider).

Obtained by Dr. A. G. Mayer.

## Family PRIACANTHIDÆ.

87. **Priacanthus cruentatus** (Lacépède).

Not rare. New to the fauna of the United States.

## Family LUTIANIDÆ.

88. **Lutianus griseus** (Linnæus).

Common.

89. **Lutianus jocu** (Bloch & Schneider).

Found south of the Tortugas.

90. **Lutianus apodus** (Bloch & Schneider).

Common.

91. **Lutianus aya** (Bloch).

Reported by fishermen; not seen.

92. **Lutianus analis** (Cuvier & Valenciennes).

Caught in Bird Key channel in 8 fathoms.

93. **Lutianus synagris** (Linnæus).

Isolated individuals, largely in eel grass. (T.)

94. **Ocyurus chrysurus** (Bloch).

Very common. A specimen taken was 22.5 inches long, weighing 3.5 pounds. (T.)

95. **Etelides aquilionaris** (Goode & Bean), new genus. Figure 2.

The species, named but not described as *Anthias aquilionaris* Goode & Bean, is allied to *Etelis*, as Jordan and Evermann have shown. It belongs to a distinct genus, *Etelides*, and differs from *Etelis* in the scaleless jaws, the compressed body, the presence of an opercular spine, and the form of the dorsal fin. Scales ctenoid; gillrakers long and slender, 15 on lower limb of arch; preopercle entire; teeth very small.

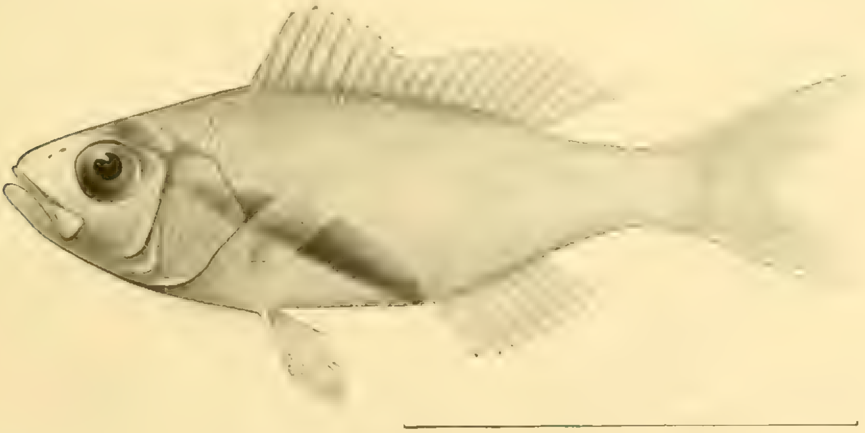


FIG. 2.—*Etelides aquilionaris* (Goode & Bean).

The structure of the upper part of the head seems essentially as in *Etelis*, the supra-occipital not encroaching on the convex vertex. Head 2.9 in length; depth 3.10 (3.70 with caudal); D. x, 10; A. III, 7; scales 7-54-13; eye 3.1 in head; maxillary 2.50; third dorsal spine 2; longest soft ray 3; caudal lobes 1.80; second anal spine 3.30; pectoral 1.70; ventral 1.85.

Body oblong, rather strongly compressed; head moderate; mouth oblique; jaws equal, the maxillary reaching front of pupil, its tip scarcely wider than the preorbital; posterior nostrils twice as long as anterior; preopercle with both limbs entire; 5 rows of large scales on cheek; snout and both jaws scaleless; temporal region scaled; opercle and interopercle well scaled; opercle ending in a sharp spine about half diameter of pupil; preorbital entire; scales on body ctenoid, adherent, evenly covering the surface; dorsal deeply notched, the first spine short, the second nearly as long as third; the rest progressively shorter to the ninth and tenth; first rays of soft dorsal progressively lengthened; lateral line slightly curved upward; caudal lobes equal; second anal spine slender, slightly shorter than third, which is about as long as the soft rays; ventral slightly behind axil of pectoral.

Color silvery, doubtless bright red in life, a broad dark shade from interorbital area across temples, opercular spine and axil to vent, well defined on the lower edge, but diffuse above. On the sides the color seems to be below the scales in the peritoneum, but the same marking is continued across the head. Sides below this mark bright silvery.

One specimen 1.87 inches long was obtained by Dr. Thompson in the Gulf Stream toward the Carolina coast.

## Family HÆMULIDÆ.

96. **Hæmulon album** Cuvier & Valenciennes.

Said to occur near Bird Key; not seen.

97. **Hæmulon macrostomum** Günther.

Described from Garden Key by Dr. Bean, 1883 (as *Diabasis fremebundus*).

98. **Hæmulon parra** (Desmarest).

Frequently taken.

99. **Hæmulon melanurum** (Linnæus).

Known only from around a group of coral heads, to the southwest of Bush Key; not known to local fishermen. New to United States fauna. (T.)

100. **Hæmulon sciurus** (Shaw).

Bush Key, in eel grass. (T.)

101. **Hæmulon plumieri** (Lacépède).

Everywhere.

102. **Hæmulon flavolineatum** Cuvier & Valenciennes.

Occasional.

103. **Brachygenys chrysargyreus** (Günther).

Frequent.

104. **Bathystoma aurolineatum** (Cuvier & Valenciennes).

Reported by Jordan in 1884.

105. **Bathystoma rimator** (Jordan & Swain).

Extremely abundant. (T.)

106. **Bathystoma striatum** (Linnæus).

Color of an example 2.5 inches long, blue gray above, silvery below; strong brown-black band from snout to peduncle; peduncle spot oblong, wide as pupil, black, long axis horizontal; lateral line dark, continued on head as a brown line. Narrower lines, not so dark, one above each eye and meeting on the forehead, run to end of soft dorsal and continue on top of peduncle; a median line begins on head between eyes and runs to and along base of dorsal. In older examples dorsal and caudal are dusky; in younger ones fins are all plain; front of lower lip dusky. (T.)

**107. Anisotremus surinamensis** (Bloch).

Recorded by Garman from the Tortugas.

**108. Anisotremus virginicus** (Linnæus).

Around coral heads on reefs. (T.)

### Family SPARIDÆ.

**109. Calamus calamus** (Cuvier & Valenciennes).

Occasional.

**110. Calamus bajonado** (Bloch & Schneider).

Reported about the Tortugas.

**111. Calamus arctifrons** Goode & Bean.

Many young seined in the eel grass.

**112. Lagodon rhomboides** (Linnæus).

Common.

**113. Archosargus probatocephalus** (Walbaum).

Reported to occur.

**114. Diplodus holbrooki** (Bean).

Obtained by Dr. Mayer.

### Family GERRIDÆ.

**115. Eucinostomus pseudogula** (Poey).

Several seen. New to the fauna of United States.

**116. Eucinostomus harengulus** Goode & Bean.

Several taken.

**117. Eucinostomus gula** (Cuvier & Valenciennes).

Taken by Dr. Henshall at Garden Key.

**118. Xystæma cinereum** (Walbaum).

In sandy places, a foot or so above the bottom, swimming rapidly, then remaining motionless. Called "narrow shad" by the fishermen. (T.)

### Family KYPHOSIDÆ.

**119. Kyphosus incisor** (Cuvier & Valenciennes).

Dorsal XI–14; A. III–13. Lead gray; large, regular silvery-gray blotches; those under chin with a greenish-yellow tinge at edge; those on abdomen and lower sides also margined, but with reddish brown; soft dorsal and caudal straw tinged. When the fish is in the sargassum these markings are pale brown and silvery. (T.) New to the United States fauna.

**120. Kyphosus sectatrix** (Linnæus).

Frequent.

### Family MULLIDÆ.

**121. Pseudupeneus martinicus** (Cuvier & Valenciennes).

In coral heads.

**122. Pseudupeneus maculatus** (Cuvier & Valenciennes).

Occasional. Life colors, upper part of head and back gray-green, uniform when in motion, when at rest mottled with red brown; a dark red-brown line from tip of snout to end of caudal peduncle, in region of eye a little wider than pupil, in middle of body wider, at tip of peduncle narrower than pupil; where this line crosses the iris the latter is red in front and red and brown behind; below this line whitish with a light-green tinge; at times there occurs in this region a broken band forming a light blotch anterior to line of gill slit, one below first dorsal spine, two between dorsals; first dorsal colorless with occasional narrow spots; second dorsal colorless with two rows of fine, white-gray dots, outer one extending from middle of first spine back and downward to base of last spine; caudal hyaline; anal colorless; pectoral reddish tinged; ventrals whitish-gray tinged; barbels bright yellow, folded in jaw when the fish is at rest; mottlings on head, a dot forward and mesial from each eye, a pair of dots posterior to these; two in median line forward of first dorsal, one at base of fin, one between it and second dorsal; second dorsal mottled at base, two spots between second dorsal and caudal.

Found swimming close to sandy bottom in eel grass on flat west of the Tortugas, at depth of 3 feet. (T.)

## Family SCIÆNIDÆ.

123. **Odontoscion dentex** (Cuvier & Valenciennes).

Quite common.

Life colors of an example 2.73 inches long: Back dirty gray with a blue and coppery-yellow sheen; dorsal and caudal yellowish gray with fine black punctations; caudal with one-eighth inch border, quite blackish; pectoral colorless, very black at base; ventral and anal with white-gray punctations; head coppery hue, wart over eye; snout bluish, opercles speckled with gray dots; region below pectoral white, very few black spots; body below lateral line with about 9 nearly horizontal rows of gray spots, which upon close examination seem to be composed of a yellowish-gray spot on each scale with a few black-gray dots about posterior margin. Specimen found in coral head at a depth of 1 fathom, west of Tortugas. (T.)

New to the fauna of the United States.

124. **Menticirrhus americanus** (Linnæus).

Taken by Dr. Henshall at Garden Key in 1889

125. **Menticirrhus littoralis** (Holbrook).

One small specimen.

126. **Eques acuminatus** Cuvier & Valenciennes.

Occasional.

127. **Eques pulcher** Steindachner.

About coral heads and sea urchins; seemingly panic stricken when more than a foot from shelter. (T.) New to the United States fauna.

128. **Eques lanceolatus** Cuvier & Valenciennes.

One specimen, taken in 6 fathoms.

## Family POMACENTRIDÆ.

129. **Chromis insolatus** (Cuvier & Valenciennes).

Recorded by Porter & Moore in 1878, from Port Jefferson.

130. **Pomacentrus fuscus** Cuvier & Valenciennes.

One of the commonest species in the group.

Color of an example 1.73 inches long: Body from above pectoral to beginning of peduncle dusky orange, top of head darker; body below, orange; posterior half of soft dorsal, soft anal and caudal and ventral brighter orange; on body distinct brown vertical stripes, the darker edges of scales; spot on back and dorsal fin oblong, as wide as eye, long axis parallel to spines, not ocellated; peduncle spot as a saddle, wide as pupil; axillary spot brown black.

Color of a specimen 2.25 inches long: Body dusky brown, lighter below; caudal peduncle, caudal, posterior part of soft dorsal and anal, and ventral yellow orange; ventral with a faint sooty lower margin; vertical bars most pronounced over middle half of body; dorsal spot shaped as above, but with sapphire blue border; peduncle spot saddle-like, size of pupil; axillary spot brown black.

Specimen 3 inches long: Sooty brown above, lighter below, where lines are visible also on caudal peduncle; caudal yellow brown; posterior part of soft dorsal and anal a lighter brown than rest of fin; ventral spines dusky, nearly yellow brown; dorsal spot barely visible as a black blotch; peduncle spot plain, a trifle wider than pupil; axillary spot black, extending on base of fin as sooty.

All these specimens taken with dynamite at the same explosion, among coral heads at depth of 6 feet.

Specimen 2.45 inches long: Orange buff, same shade over almost entire body; vertical lines plain, of dusky brown; dorsal spot black brown; peduncle spot black; pectoral rays black; axillary spot black on top of axil, dusky slightly over the base of fin. Tip of dorsal and anal orange; caudal and ventral deep orange.

### 131. **Pomacentrus analis** Poey.

An example 4 inches long was sooty black, paler on abdomen; scales of head, cheek, and upper half of body with a round blacker spot, this surrounded by a paler zone; scales of abdomen with pale central spots; tip of caudal peduncle a trifle pale; dorsal with submarginal pale zone, interspinous web with dusky spot. Caudal upper rays and tip pale and yellow; spot on anal fin grayish blue, faint.

Life color of an example 4.37 inches long: Caudal peduncle scarcely, if any, lighter than body; caudal anterior two-thirds quite yellowish; posterior third duskier, margin somewhat black; anal spot gray blue; upper lobe of caudal three-sixteenths inch longer than lower.

Life colors of an example 3.87 inches long: Pinkish white from above sharp line over and posterior to eye and a little before end of dorsal; dorsal fin to about last five soft spines same color; this on body shades gradually to gray brown.

In another color condition the same fish was very light gray brown; center of each scale fawn colored with dark spot on posterior border; caudal, anal, and soft dorsal margins dusky. Again, entirely pinkish white; body dusky; axillary spot dark. (T.)

### 132. **Pomacentrus leucostictus** Müller & Henle.

An example 3.93 inches long has the caudal with a fine black rim to top and bottom of outer rays; anal with a fine black rim; peduncle spot conspicuous as is also the axillary.

Another specimen, 3.63 inches long, very yellow below; anal broadly margined, below sooty; dorsal spot visible; none on peduncle; spots on back and head very blue. (T.)

### 133. **Pomacentrus planifrons** Cuvier & Valenciennes.

Nine examples, agreeing perfectly with the account given by Dr. Günther, were secured. New to the United States.

### 134. **Abudefduf marginatus** (Bloch).

Very common. (T.)

### 135. **Abudefduf taurus** Müller & Troschel.

One specimen 2 inches long. Dorsal spines 13; scales 25; propercle very slightly uneven on the edge, suggesting serrature.

Dusky bands fainter than in *Abudefduf marginatus*, twice as broad as the interspaces and growing fainter below; a faint band on caudal peduncle, making 6 dark bands in all; fins all dusky. This species is distinguished from *A. marginatus* by the larger scales, the much broader and fainter cross-bands, of which 6 rather than 5 are distinct, and by the rather broader preorbital. It was hitherto known from two examples only, the type from the Barbados, and the type of *Glyphisodon rudis* from Cuba. *Abudefduf declivifrons* of the Panama fauna is very close to this species.

Life color: Body bands brown, blacker at back; interspaces grayish yellow. This fish is readily distinguished from *A. marginatus*, being very much darker.

One other specimen, 3 inches long, was observed at the Tortugas, at the south jetty, in water 6 feet deep, in company with three specimens of *A. marginatus;* it seems to swim in schools. This individual was watched for nearly an hour.

Locality: Loggerhead Key, low-tide puddles west of light-house. Several seen November 11. (T.)

Another specimen had the head 3½ in length; depth 1¾; D. xiii–12; A. ii, 12; eye 3 in head; snout 4 in head; scales 4–25, 19 pores.

Color, cross bands brown; abdomen and base of caudal bright yellow, each scale below lateral line pale centered; snout low and blunt; ventrals not reaching front of anal; maxillary reaching below vertical from front of orbit; pectorals reaching beyond tips of ventrals.

This fish has a very characteristic manner of darting with the utmost rapidity from the shelter of one stone to another and hiding there until danger is past; it can be seen in the open only as a yellow and brown striped flash. (T.)

136. **Microspathodon chrysurus** (Cuvier & Valenciennes).

In coral heads, shoal water, clinging closely to rock crevices; one individual was seen almost daily for over a month within a radius of a fathom from a certain nook in the coral.

An example 5 inches long was very black brown; scales of cheek and body region, except by pectoral, lighter brown with darker borders, blending with body color; scales above lateral line some with round sapphire spots, similar spots on nape, top of head, about eye and on scales of dorsal fins; caudal pure bright orange yellow, upper and lower ray brown externally, posterior margin faintly sooty; pectoral clear, rays black; ventral black. (T.)

Young black, with many large sapphire spots on the back; dorsal, anal, and ventral black; caudal and pectoral colorless.

## Family LABRIDÆ.

137. **Lachnolaimus maximus** (Walbaum).

Around coral heads.

138. **Thalassoma nitidum** (Günther).

Life color of an example 1.2 inches long: Top of head, nape, back, and top of caudal peduncle dark brown; a clear-cut white line from upper and posterior sector of eye to tip of peduncle, a trifle wider than pupil; below this a broad clear brown line; below this pure white.

As seen at night, top area light brown; first line pale straw; broad band light brown; below this band fine pale spots, giving appearance of breaking band into six; below white, pinkish; snout, broad cheek band, area posterior to eye and axil, carmine.

Life color of an example 1.5 inches long: Head from base of first dorsal, gills and cheeks dull-green blue; body dark yellowish olive green with 6 crossbar blotches, first 2 quite black, third, fourth, and fifth lighter; sixth longer than the rest, extending from one-fourth inch forward of end of dorsal to over caudal peduncle; beyond this dark areas extending over 4 scales, green interspaces over 1, 1½, or 2; body color along back more brownish green; dorsal with a black spot extending over first three webs; pectoral with a dark tip where it lies alongside and over second body blotch; third, fourth, fifth, and sixth blotches ending on level of median line; first blotch reaching to axil, base of pectoral with a crimson line where scales commence, this following a crimson blotch back of eye half as wide; a similar blotch on gill anterior to angle; body colors between first and second blotches decidedly bluish, especially in middle line; base of caudal peduncle dark, dark extending along outer three rays to tip; anal colorless, decidedly bluish scales at base; ventral colorless; belly grayish blue.

Usually seen alone, a very active fish, always apparently hastily searching for something, inspecting many crevices and nooks and then darting away. New to United States fauna. (T.)

139. **Thalassoma bifasciatum** (Bloch).

Occasional. New to the fauna of the United States.

140. **Halichœres radiatus** (Linnæus).

Occasional.

141. **Halichœres bivittatus** (Bloch).

Frequent; variable.

142. **Halichœres maculipinna** (Müller).

This specimen differs from all descriptions in having a black spot at upper base of caudal, besides the spot on the dorsal and the smaller ones at base of pectoral and last dorsal ray.

143. **Doratonotus megalepis** Günther.

Seventeen specimens of various sizes, seined in the eel grass south and west of Garden Key. These vary considerably in depth of body and height of dorsal spine. They agree well with *Dorato-*

*notus decoris* Evermann and Marsh, but seem to show that this species, with *Doratonotus thalassinus*, is identical with *Doratonotus megalepis*. Only six specimens of *Doratonotus* were hitherto known.

144. **Novaculichthys rosipes** Jordan & Gilbert.

Three specimens, the smallest less than an inch long, having the first two dorsal spines elevated; one of the larger having no traces of this, but showing the dark cross bars described in the original type. Ventrals short, blackish in spirits.

One specimen 2.31 inches long, pale brown, much mottled with lighter; quite pale beneath; on body 4 brown irregular cross bands, the first extending over first half of second dorsal web, the others extending to contiguous portions of dorsal and anal webs; brown blotch on peduncle, which forks posteriorly and ends in two darker spots on base of caudal; cheek pale; a brown line from eye nearly vertically downward; tip of chin brown; a spot on neck behind this band; ventral dark brown; iris golden, margin greenish brown above and reddish below; dorsal and anal clear, faintly yellow, brownish tinged; center of each scale paler than margin, giving the entire fish a distinctly reticulated appearance. Colored portion of dorsal containing a few pale specks. Along the median line there are patches of brown darker than general color, making diamond-shaped reticulations; lower half of bands at times becomes much darker brown than upper.

Anal broadly margined, brightest anteriorly with orange red. At times a decided pinkish flush spreads over the pale markings, especially on side and top.

Bush Key, in eel grass at depth of 1 to 2 feet. (T.) Previously known from two examples from Key West.

145. **Xyrichthys psittacus** (Linnæus).

Recorded by Dr. Bean from the Whitehurst collection, from Garden Key.

146. **Cryptotomus beryllinus** Jordan & Swain.

One specimen.

147. **Sparisoma xystrodon** Jordan & Swain.

Frequent.

148. **Sparisoma radians** (Cuvier & Valenciennes).

Two specimens. New to fauna of United States.

149. **Sparisoma hoplomystax** (Cope).

Occasional.

150. **Sparisoma niphobles** Jordan & Bollman.

One specimen, sent to the Bureau of Fisheries. Hitherto known from one example.

151. **Sparisoma distinctum** (Poey).

Recorded by Henshall in 1889 from Garden Key.

152. **Sparisoma abildgaardi** (Bloch).

Rare. New to fauna of United States.

153. **Sparisoma viride** (Bonnaterre).

Frequent. New to United States fauna.

154. **Sparisoma flavescens** (Bloch & Schneider).

Common.

155. **Callyodon punctulatus** (Cuvier & Valenciennes).

Half a dozen examples. New to United States fauna.

156. **Callyodon vetula** (Bloch & Schneider).

Frequent. New to United States fauna.

157. **Callyodon croicensis** (Bloch).

In eel grass.

**158. Callyodon evermanni** (Jordan).

A specimen sent to the Bureau of Fisheries.

**159. Callyodon cœruleus** (Bloch).

Frequent.

**160. Pseudoscarus guacamaia** (Bloch & Schneider).

Reported to occur.

### Family ILARCHIDÆ.

**161. Chætodipterus faber** (Linnæus).

Reported to occur.

### Family CHÆTODONTIDÆ.

**162. Chætodon ocellatus** Bloch.

Color, black bar not broader than eye, from and including first dorsal spine through eye down cheek to in front of gill slit; spinous dorsal, both ventrals, caudal peduncle, front of ventrals, yellow; soft dorsal, pectorals and tail colorless.

Some times a black band from middle of spinous dorsal to ventral, somewhat angular, the concave side forward; or the body may be mottled, with an oval light spot in front of angle. (T.)

**163. Chætodon capistratus** Linnæus.

Common; some specimens with an additional spot correspond to *Chætodon bricei* Smith, in which species the lower spot, vertically oblong, is in keeping with the existence of the superior one. Both may be remnants of a vertically barred ancestral type, as in *C. ocellatus*, where the fragments of broken and fading bars are more prone to be irregularly oblong than round. (T.)

A very instructive series of specimens was found. One 1.25 inches long shows both spots, the upper bordered with white. Another specimen 1.6 inches long has the upper spot represented by a dusky area not edged with pale. One 1.25 inches showed no trace of the upper spot. The largest is 2.58 inches long.

**164. Pomacanthus arcuatus** (Linnæus).

Frequent.

**165. Pomacanthus paru** (Bloch).

Frequent.

**166. Holacanthus tricolor** (Bloch).

One specimen. New to United States fauna.

**167. Holacanthus ciliaris** (Linnæus).

Frequent. Specimens 2 inches long show the transition from the young to adult coloration. Dorsal and anal widely marked with blue, caudal abruptly yellow; opercle behind the nape stripe, base of pectoral, and abdomen gray-green, scales with paler edges. Three body bands, faint stripes between them.

### Family ACANTHURIDÆ

**168. Hepatus cœruleus** (Bloch & Schneider).

Life color, pure and bright canary yellow all over. Rim of dorsal and anal tinged with blue in specimens 2.5 inches long and over.

Found alone as far as companions of its own species are concerned, but always in a school of small grunts and parrot fish. It is a very active and nervous little fish. *Pomacentrus fuscus* often chases it a considerable distance and nips at its tail.

Color of an example 5.79 inches long, light yellowish olive, with undulating lines much lighter; spine yellow; dorsal and anal duskier, margined with blue; blue undulating lines on dorsal, only barely discernible; caudal lighter than body, dusky posterior margin. (T.)

**169. Hepatus hepatus** (Linnæus).

### Family BALISTIDÆ.

170. **Balistes carolinensis** Gmelin.

In the sargassum.

171. **Balistes vetula** Linnæus.

Often taken by the fishing smacks which come from Cuba for groupers. The skin is used for polishing—as sandpaper.

### Family MONACANTHIDÆ.

172. **Cantherines pullus** (Ranzani).

Recorded by Porter and Moore from Fort Jefferson.

173. **Monacanthus ciliatus** (Mitchill).

Occasional.

174. **Monacanthus hispidus** (Linnæus).

Frequent.

175. **Ceratacanthus schoepfi** (Walbaum).

Recorded by Porter and Moore from Tortugas.

### Family OSTRACIIDÆ.

176. **Lactophrys triqueter** (Linnæus).

Recorded by Goode from the Tortugas.

177. **Lactophrys bicaudalis** (Linnæus).

One seen. New to United States fauna.

178. **Lactophrys trigonus** (Linnæus).

Occasional, in the sargassum.

179. **Lactophrys tricornis** (Linnæus).

Frequent, in eel grass.

### Family TETRAODONTIDÆ.

180. **Spheroides lævigatus** (Linnæus).

Recorded by Porter and Moore from the Tortugas.

181. **Spheroides spengleri** (Bloch).

Common, browsing on tops of eel grass. (T.)

182. **Spheroides testudineus** (Linnæus).

Recorded by Porter and Moore from Fort Jefferson.

### Family DIODONTIDÆ.

183. **Diodon hystrix** Linnæus.

Not seen.

184. **Diodon holacanthus** Linnæus.

Color of an example 3.87 inches long, yellowish olive brown, spots very black, blotches brown, lighter than over eye; spines inserted in the blotches, a black triangular mark posterior to them, which they nearly but not quite cover when depressed; fins body colored, unspotted; abdomen white, light brown at base and posterior to spines; throat very white. (T.)

185. **Chilomycterus schoepfi** (Walbaum).

Frequent. It is reported that a great school visited the Tortugas several years ago, all of small size. (T.)

### Family SCORPÆNIDÆ.

**186. Scorpæna brasiliensis** Cuvier & Valenciennes.

A specimen obtained.

**187. Scorpæna plumieri** Cuvier & Valenciennes.

Recorded by Dr. Bean from Fort Jefferson.

**188. Scorpæna grandicornis** Cuvier & Valenciennes.

Color of a specimen 2.13 inches long, head olivaceous brown, finely speckled with pale; dermal flaps pinkish; a dark brown sector from lower part of eye down and back to lower part of cheek; body dark brown with gray mottling, flaps pink, some whitish; three almost black blotches along middle line of body; belly whitish, above a pink zone with two broken rows of dark brown spots with indistinct light brown zone; ventral very dark maroon, pink spines and pale posterior border; pectoral red brown, brown band at base and one about middle of fin not sharply defined; pectoral base underneath white, brown spotted; dorsal brown like body, spines and margin of web above notches pale, much dotted with white; soft dorsal a trifle dusky, with reddish marginal band, pale mid band; caudal red brown, with pale margin, two pale bands, one at base with a white dermal flap anteriorly. (T.)

### Family COTTIDÆ.

**189. Hemitripterus americanus** (Gmelin).

One specimen found inside of Bush Key and deposited in the Brooklyn Institute of Arts and Sciences. This is the most southern record on the Atlantic coast of North America for a member of the sculpin family, Charleston being the limit before noted. (T.)

### Family TRIGLIDÆ.

**190. Prionotus roseus** Jordan.

A specimen sent to the Bureau of Fisheries.

Body color, pinkish gray; head a trifle lighter gray, with very small pink-brown blotches; roof of mouth rust-red; behind angle of mouth a pink blotch; on back, opposite fifth to sixth dorsal spines, two brown spots with ill-defined edges from above downward, forming the outer boundary points of a lighter brown square blotch, opposite eighth to ninth dorsal spines a similar marking; opposite fifth web a round brown spot, these spots three-sixteenths inch apart; behind soft dorsal, the two spots so close together as to form a blotch nearly one-eighth inch broad. Throat, abdomen, and under part of tail pure white; body and tail markings border this white region as pinkish blotched oblongs starting obliquely upward; on body a similar row of indistinct pink blotches from axil obliquely upward and backward, ending under second spot below soft dorsal; roughly 15 blotches; feelers cream-colored, with 8 light brown cross-bands, these about parallel when fin is folded to body; under surface of pectoral for anterior two-thirds gray, remainder black gray; dorsal yellow gray, mottled at base; spines white and pink; web of first to fifth spines much darker gray; half of fifth and remainder quite hyaline; soft dorsal rays white; three rows of pink gray spots; tips almost salmon, web hyaline; last two gray and gray black, respectively; caudal spines white, two broad bands of pearly gray, upper margin white and pink gray barred, lower pure pink; tip of all spines and webs except lowest dark gray; anal white, pink blush on last spines and webs; ventral white. (T.) This fish was hitherto known only from spewings of red groupers from the snapper banks off Tampa and Pensacola.

**191. Prionotus tribulus** Cuvier & Valenciennes.

Reported by Garman from Nutting's collection of 1896.

### Family CEPHALACANTHIDÆ.

**192. Cephalacanthus volitans** (Linnaeus).

Recorded by Porter and Moore from Fort Jefferson.

### Family GOBIIDÆ.

**193. Eviota personata** Jordan & Thompson, new species. Figure 3.

Head 3.9 in length; depth 4.30 (5.30 in total); D. VI-11; A. 11; V. I, 5; scales 9, 27; eye 2.90 in head; maxillary 2.70; longest dorsal spine 2.50; longest soft ray 1.50; caudal 1; pectoral 1.05; ventral 1.10.

Body rather elongate, compressed, the dorsal profile evenly curved; mouth small, oblique, the lower jaw considerably projecting, the narrow maxillary extending a little beyond front of eye; teeth sharp and irregular; lower jaw thin; head naked; preopercle entire; gill-membrane narrowly connected with isthmus; scales large, finely ctenoid; nape, base of pectoral, and breast naked; dorsals well separated, the first low, sixth spine highest; soft dorsal higher; anal rather low; pectoral long, reaching vent; ventrals separate, rays I, 5; branched in the usual fashion; inner ray also branched and shorter than the others.

Color in spirits, pale, perhaps greenish in life, the dorsals and anal fin with fine black dots; a dark streak along middle line of nape; a dark shade along base of each dorsal and anal; a dark streak along middle line of side; side of head about eye jet black, this color forming with the eye a triangular area, which fades out into dark speckling on snout and is bounded below eye by a definite sharp line which separates the dark area from the silvery of the cheeks; an oblong horizontal black blotch before base of pectoral; an area of black dots on opercle and one above it.

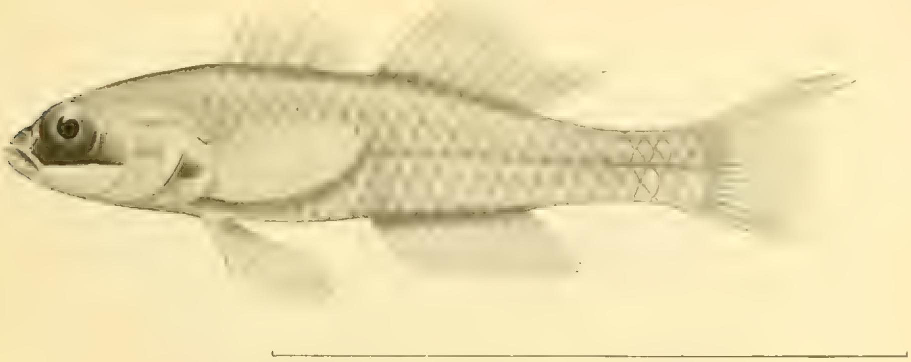


FIG. 3.—*Eviota personata* Jordan & Thompson, new species. Type.

A single specimen of this remarkable little goby was taken by Doctor Thompson on the reef at Garden Key, and is numbered 8410 in Stanford University Museum.

**194. Mapo soporator** Cuvier & Valenciennes. We can not distinguish this species from *Mapo fuscus* (*albopunctatus*) of the Pacific.

Common.

**195. Rhinogobius glaucofrænum** (Gill).

In eel grass.

**196. Rhinogobius tortugæ** (Jordan).

Only one specimen seen.

**197. Gnatholepis thompsoni** Jordan.

Type with about 10 faint dark squares down back, dots in these quincuncially arranged; below these squares a light line; another row of blotches on level of eye, extending to tail; below this another light line; at level of pectoral 6 large blotches, the darkest; the dots in all these blotches follow parallel lines; caudal faintly speckled; dorsal more so; ventral cloudy gray; pectoral color of body, which is coral sand colored; above each pectoral a round fawn-colored spot; anal and lower half of caudal tinged with gray (this portion of body buried in sand when at rest); iris yellow; over eye a dark brown line as long as eyeball is deep, not as wide as pupil, below eye extending vertically downward, and a trifle broader than above, nearly as broad as pupil.

A bottom species moving very quickly from spot to spot, about 6 inches at a time. Frequently attacked by *Pomacentrus fuscus*. Found about coral heads, Bush Key. (T.)

**198. Elacatinus oceanops** Jordan.

Tortugas, west shoal, among coral heads at depth of 6 feet. Always clinging to brain coral; endeavoring to shelter itself in bottom of groves. When hunted, it goes from one head to another, swimming very curiously, in a zig-zag course, stopping at each turn, moving with great speed between stops and coming to a perfect standstill at each change of course. (T.)

## Family OPISTHOGNATHIDÆ.

**199. Opisthognathus macrognathus** Poey.

Reported by Jordan in 1884, from Garden Key, as *Opisthognathus scaphiurus*.

**200. Gnathypops maxillosa** (Poey).

Reported by Bean in 1883, from Garden Key.

**201. Gnathypops aurifrons** Jordan & Thompson, new species. (Fig. 6.)

Head 3.5 in length; depth 3.85 (4.55 with caudal); D. 26; A. 18; P. 18; scales 42, 106; eye 2.90 in head, 2.50 times length of snout; maxillary 1.60; longest dorsal ray 1.50; caudal 1.15; longest anal ray 1.65; pectoral 1.60; ventral 1.15 times length of head.

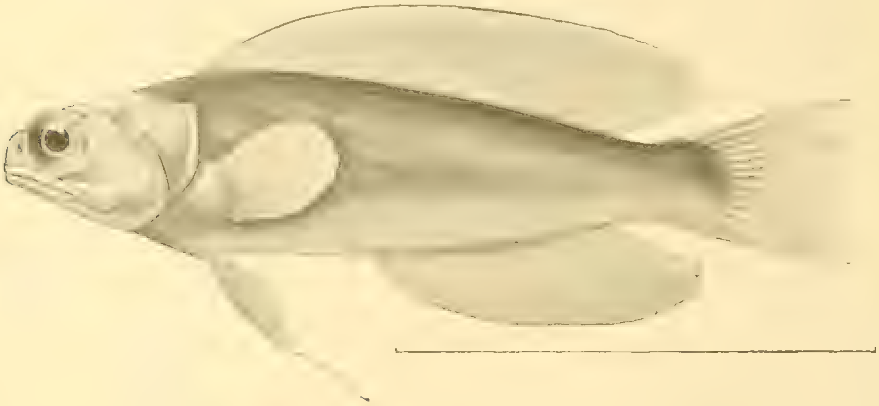


FIG. 4.—*Gnathypops aurifrons* Jordan & Thompson, new species. Type.

Body oblong, moderately compressed, deepest at the ventrals; head moderate, the short snout abruptly decurved; eye large; maxillary moderate, its tip about half the eye's diameter behind the eye; teeth long and sharp, some of the posterior ones on lower jaw curved back; vomer with teeth; lower jaw slightly included. Head naked; body covered with very small scales, the nape naked; lateral line running very high, ceasing just behind the middle of the dorsal; dorsal fin high, its posterior rays highest; no distinct spines; caudal truncate; anal high, similar to dorsal; pectoral moderate, rounded, almost reaching vent. Ventral very long, its second ray ending in a filament as long as the rest of the fin, and reaching well beyond front of anal.

Color in life, according to a sketch by Doctor Thompson, hyaline green; a large golden patch on top of head; fins faintly greenish; a narrow dark edge to the dorsal. In spirits, plain pale olive with the dark streak on the edge of the dorsal fin.

A single specimen not quite two inches long, No. 8413, Stanford University Museum, was taken by Dr. Thompson on the coral reef at Garden Key.

The species is nearest *Gnathypops mystacina*, but differs in the larger number of anal rays, the longer lateral line, the higher rays, and in numerous minor respects.

## Family DACTYLOSCOPIDÆ.

**200. Gillellus semicinctus** Gilbert.

One specimen 2.13 inches long, color very light gray, with fine greenish gray cross-bands, faintly margined with black dots, the anterior 4 inclosing a median red dot; bands broadest on back, narrowing suddenly at side before ending above median line; first band through base of anterior dorsal, broad and irregularly rectangular; anterior to this on nape a four-sided blotch, wider at one end, pure gray with green-gray edges; second band under seventh dorsal spine, about half as wide as first; remainder about same width and dividing the body into about four equal sections; between first, second, third and fourth body bands is a pale fawn-colored medianly placed figure extending only a little way each side of dorsal fin; between fourth and fifth a trace only of these marks. (T.)

## Family URANOSCOPIDÆ.

**203. Execestides egregius** Jordan & Thompson, new genus and new species. (Figs. 4 and 5.)

Head 2.15 in length; depth 3.30 (4.05 with caudal); D. 12; A. 17; P. 22; V. I, 5; eye 4.30 in head; snout 5.30; maxillary 2.30; opercle in head, 2.20; longest dorsal ray 4.10; caudal 2.05; longest anal ray 3; pectoral 1.80; ventral 3.

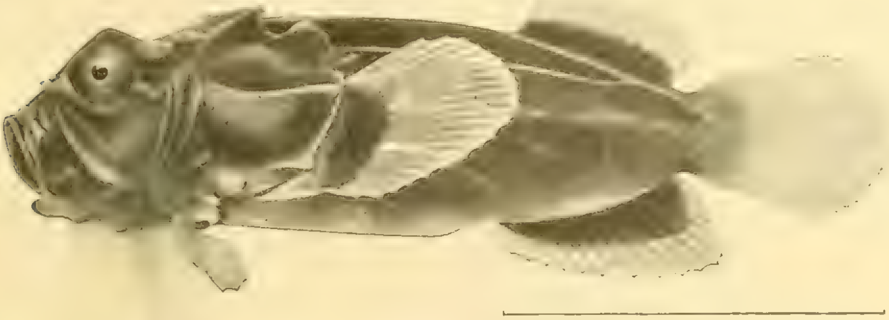


Fig. 5.—*Execestides egregius* Jordan & Thompson, new species. Type.

Body oblong, not compressed; the head broad and depressed, very large, monstrous in form, the preopercular angle developed as a long flattened wing-like appendage, without spine, its length 2.90 in head; number of blunt ridges radiating from lower part of cheek; mouth moderate, almost vertical, the lower jaw projecting; no appendage on chin; maxillary very broad; teeth small, even. Top of head broad, concave, the interorbital space about twice diameter of eye; top of head a transverse ridge between eyes; a tubercle with radiating ridges on each parietal; 2 blunt ridges at nape; opercle very long, without spine, but with a strong median ridge; a smaller ridge on subopercle. Scales none; lateral line running high, crooked, close to base of soft dorsal posteriorly; no spinous dorsal; soft dorsal small, opposite the anal, which is higher and longer; caudal rounded; pectoral large, reaching past front of anal; ventral small, well forward, inserted under preopercle.

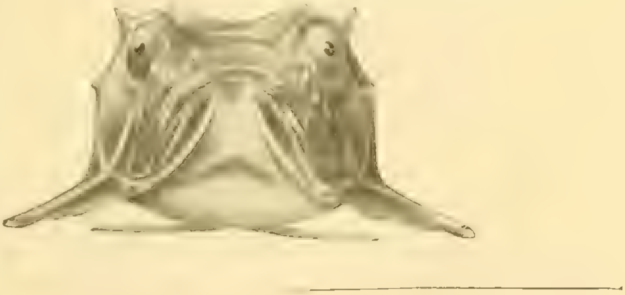


Fig. 6.—*Execestides egregius* Jordan & Thompson. Type.

Color blackish, made of dark points; fins pale, with a blackish area at base of each; a pale streak along lateral line and one across base of dorsal.

One specimen, No. 8411, Stanford University Museum, 2.3 inches long, was taken by Doctor Thompson on the reef at Garden Key.

It represents a new genus of *Uranoscopidæ* allied to *Kathetostoma*, but the armature of the head totally different, notably the expanded preopercle.

*Execestides* (Ἐξεκεστιδής) was a citizen of Athens, with a strange and barbarous lineage (Aristophanes).

### Family ECHENEIDIDÆ.

**204. Leptecheneis naucrates** (Linnæus).

A single specimen. Often found attached to large jew-fishes. (T.)

### Family BLENNIIDÆ.

**205. Acteis macropus** (Poey).

Reported by Garman from the Tortugas.

**206. Acteis moorei** (Evermann & Marsh).

Abundant. Heretofore known only from the type taken in Porto Rico.

Life colors, general color gray white; dorsal hyaline; 8 gray blotches extending over second and third spines, between these white and black dots; soft dorsal with three rows of dots; from eye to snout a dark line, iris light yellow with brown-red squares; 8 dark red-brown bands across body, center of band darker than above or below; cross-bars beginning at colored blotches on dorsal; 1 band on caudal peduncle; top of peduncle whitish; 2 rows of dots on tail; lateral line whitish. On dark bottom this fish is white and black.

A count of the spines and rays in dorsal fin of 43 specimens shows the following variations: XIX, 9, one specimen; XXI, 9, two specimens; XXI, 10, nine specimens; XXI, 11, one specimen; XXII, 8, one specimen; XXII; 9, twenty-three specimens; XXII, 10, six specimens. In 70 per cent the total is 31 fin supports, and in over 50 per cent the formula is XXII, 9. The type for this species has XXI, 11, which figure only occurs once in the Tortugas series. (T.)

**207. Lepisoma nuchipinne** (Quoy & Gaimard).

One specimen captured on west shore of Loggerhead Key.

**208. Ericteis kalisheræ Jordan.**

Shoal water inside of Bush Key. Three specimens known.

**209. Auchenopterus fasciatus** (Steindachner).

Six specimens.

Color, dark brown, abdomen salmon brown; white irregular mark on gill, sharply edged with dark brown; inside of this a pale brown mark smaller and of same general shape, with three pale specks in it; from this mark a series of irregular pale blotches extending three-fourths down body to level of pectoral; body indistinctly banded; dorsal lighter brown than body with seven dark brown bands continued upon it; anal with fine dark brown bands (darker than the dorsal or brown of body), these corresponding to posterior five on dorsal; caudal pale, with 4 or 5 rows of light brown dots, its base very dark brown. (T.)

**210. Blennius favosus** Goode & Bean.

Common; the male recorded by Garman in 1896 as *Blennius pilicornis*.

Color of one specimen: Brown specks and lines principally on spinous dorsal; inner two-thirds of dorsal opaque bluish; nine dark-brown blotches on back; base of spines at these blotches with a darker brown dot; edge of soft dorsal and caudal somewhat orange red; at times body above level of middle of pupil much lighter brown than below, this lighter color extending on forehead and cheek below eye to upper lip, while snout and gills are dark brown; pectoral rays with blue dots beyond the reticulations of base; webs hyaline; rays yellowish-gray brown.

Life color of another specimen, seven shiny blue-white spots alongside, with a tendency to be rectangular; tips of pectoral and caudal orange; pupil emerald; belly from vent to ventral fins silvery blue white; on second dorsal spine a black blotch; at base of spines a dot, occasionally one without dot; eye cirrus branched; upper parts olive brown, head and opercle plain dark brown; a fine speckling of red-brown dots below over entire body and dark brown above middle line, these latter in a row from pectoral to tail; space between base of dorsal spines and top rows on body checkered dark brown and lighter. (T.)

**211. Blennius cristatus** Linnæus.

Head gray-green, with green blotch from eye to base of dorsal; a light spot at angle of upper and lower lip; one radiating downward and backward toward pectoral, one downward to behind angle of mouth, one toward upper lip halfway between angle and front blotch on cheek; tip of operculer spine dark green; around eye gray-blue dots; lower lip and branchiostegals pale blackish, blotch on front of lower lip; cirri on nape gray with three red bands about each one; tip of each dorsal spine pale, with dark blotches, lower part of webs contiguous to three body blotches; light spot just posterior to origin of spines; on first dorsal web an oblong spot, this changing from gray-blue to steel-blue with a darker and at times a lighter border; on nape and shoulders many gray-blue spots with brick-red centers; pupil golden on inner rim; body same as head, possibly lighter posteriorly; above and on region swept by pectoral greener than the rest; no white spots; region above anal with bluish-white dots, these arranged in oblique forward and downward slanting rows above middle line corresponding to spaces (average of 6 dots each) below middle line, irregularly placed; along middle line twelve ill-defined brown dots, smaller than pupil, these dots grouped in pairs; anal with a dark band and a white spot behind each spine; edges pale; caudal pale at tip, inside this a faint red-brown shade, general color more yellow-green than body; back gives appearance of five brown square blotches, extending one-third distance down sides; base of pectoral with a white blotch below, two above partly covered by posterior part of gill-membrane; base of fin pale, rear part with spots, pale spot in center, another row of dark spots. (T.) Inside of mouth brick-red.

## Family FIERASFERIDÆ.

**212. Fierasfer affinis** Günther.

Recorded by Professor Putnam from Würdemann's collection of 1874, from the Tortugas.

## Family BROTULIDÆ.

**213. Ogilbia cayorum** Evermann & Kendall.

Color, pale brown, with very fine brown specks.

These fish hide under small stones and bury themselves partly in the sand; when disturbed they swim feebly, like a tadpole, the body kept straight and propelled with a wavy motion from tail to vent and of dorsal and ventral fins. They swim straight backward a little. (T.)

Twelve specimens taken; hitherto known only from the type.

## Family REGALECIDÆ.

**214. Regalecus glesne** (Ascanius).

Reported by the keeper of the Loggerhead Light, who furnished a good description of the fish, to have come ashore after a storm. (T.)

## Family PLEURONECTIDÆ.

**215. Platophrys ocellatus** (Swainson).

Occasional.

## Family ANTENNARIIDÆ.

**216. Pterophryne gibba** (Mitchill).

This species lives in the center of clumps of sargassum. Except for slight movement of the pectoral fins, it remains very quiet. (T.)

In the early part of February, 1902, when there occurred a strong southerly blow, and a great quantity of sargassum weed drifted ashore, these fish were taken in quantity. They rest almost motionless among the branches, which they grasp with their hand-like pectorals. They eat the shrimp and crabs and are also cannibalistic.

When separated from a clump of weed, they swim rather feebly downward and then seek shelter under another mass. When frightened they are capable of swimming a few feet with great rapidity and then coming to a sudden halt. (T.)

217. **Antennarius ocellatus** (Bloch & Schneider).

Recorded by Goode and Bean in 1896.

218. **Antennarius multiocellatus** (Cuvier & Valenciennes).

Reported by Lieutenant Wright in 1863, from Garden Key. His specimen is the type of *Antennarius annulatus* Gill.

The following 16 species were taken by Dr. Thompson in the Gulf Stream, on the northward cruise of the steamer *Chesapeake:*

**Etelides aquilionaris** (Goode & Bean).

**Hippocampus hudsonius** De Kay.

Two specimens: Spines on body all long and relatively sharp, body much mottled and streaked with dark, but without coral markings.

**Caranx hippos** (Linnæus).

**Caranx bartholomaei** (Cuvier & Valenciennes).

Young with about 10 narrow, dark cross bands.

**Seriola fasciata** (Bloch).

**Peprilus paru** (Bloch).

Many young with low fins.

**Psenes maculatus** Lütken.

Two specimens apparently of this species. Body with five black cross bands.

**Amia americana** (Castelnau).

A very young individual, unspotted, perhaps of this species.

**Abudefduf marginatus** (Bloch).

Many young.

**Tautogolabrus adspersus** (Walbaum).

**Canthidermis sobaco** Poey.

Two small specimens, gray, with 3 diffuse, dark cross bands, and numerous dark spots, 3 black blotches below soft dorsal and one below spinous. In the younger one the bands are fainter, the black spots on middle band more distinct. These specimens correspond to *Canthidermis asperrimus* Cope, but are doubtless the young of *C. sobaco.*

**Monacanthus hispidus** (Linnæus)

Several.

**Pollachius virens** (Linnæus).

**Urophycis tenuis** (Mitchill).

One 4 inches long, with many fry.

**Pseudopleuronectes americanus** (Walbaum).

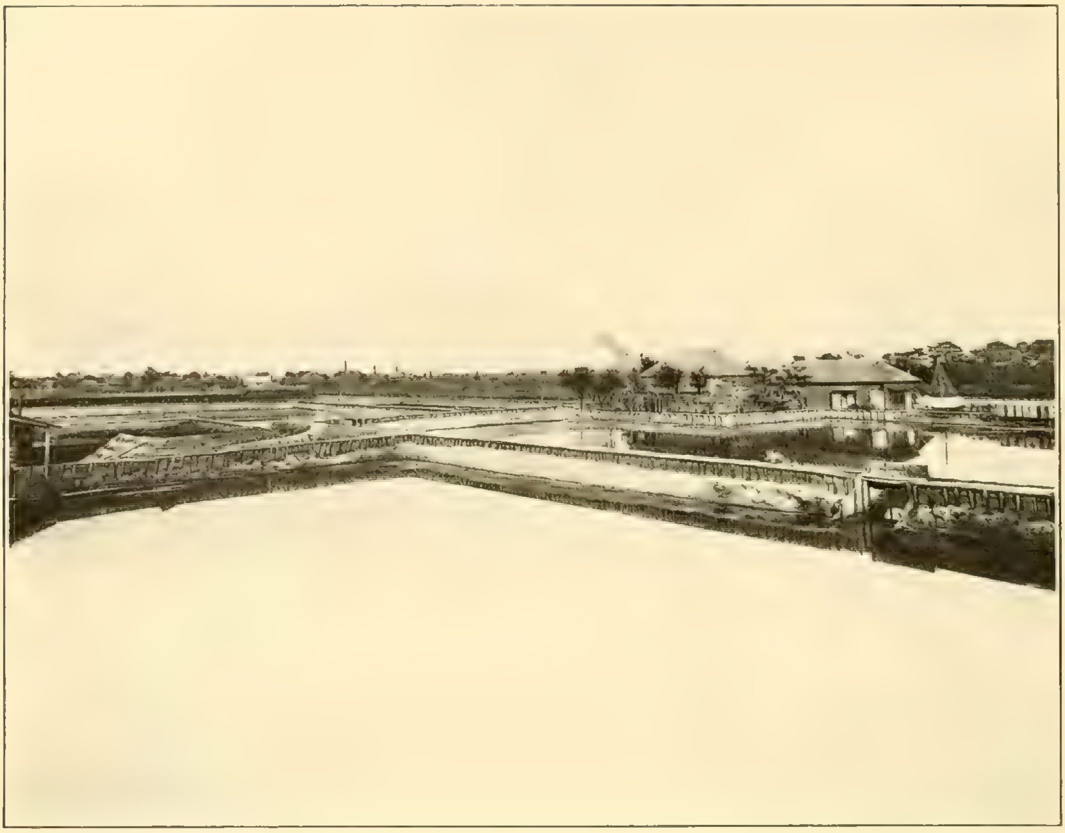
**Pterophryne gibba** (Mitchill).

# THE CULTIVATION OF MARINE AND FRESH-WATER ANIMALS IN JAPAN.

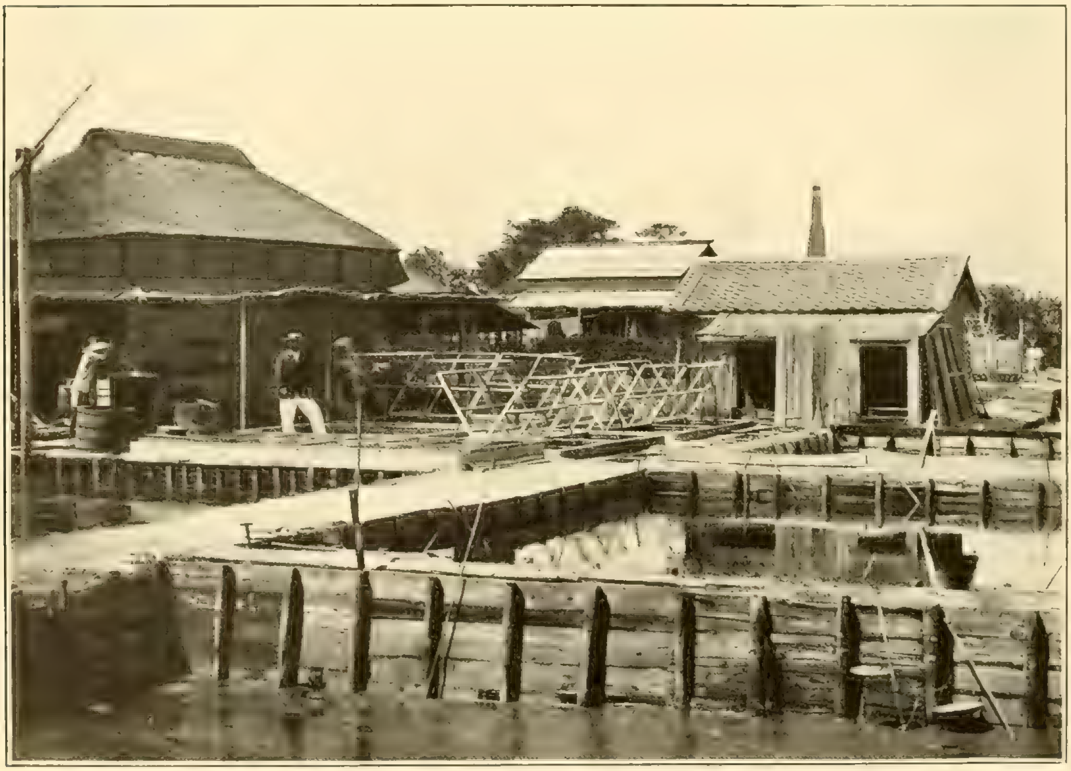
By K. MITSUKURI, Ph. D.,
*Professor of Zoology, Imperial University, Tokyo, Japan.*

## CONTENTS.

| | Page |
|---|---|
| Introduction | 261 |
| The snapping turtle | 262 |
| The gold-fish | 268 |
| The carp | 275 |
| The eel | 276 |
| The gray mullet | 277 |
| The salmon and trout | 278 |
| Pisciculture in Formosa | 279 |
| The oyster | 280 |
| The pearl oyster | 285 |
| The ark-shell | 286 |
| The razor clam | 288 |
| Barnacles | 289 |
| Miscellaneous: Pinna, egg-cases of gastropods, sea clam, round clam, basket clam, trepang, laver, "funori" | 289 |



1. VIEW OF A TURTLE FARM, FUKAGAWA, TOKYO, JAPAN.



2. VIEW IN A GOLD-FISH BREEDER'S ESTABLISHMENT.

# THE CULTIVATION OF MARINE AND FRESH-WATER ANIMALS IN JAPAN.[a]

By K. MITSUKURI, Ph.D.,
*Professor of Zoology, Imperial University, Tokyo, Japan.*

While the pasturage of cattle and the cultivation of plants marked very early steps in man's advancement toward civilization, the raising of aquatic animals and plants, on any extensive scale at all events, seems to belong to much later stages of human development. In fact, the cultivation of some marine animals has been rendered possible only by utilizing the most recent discoveries and methods of science. I believe, however, the time is now fast approaching when the increase of population on the earth, and the question of food supply which must arise as a necessary consequence, will compel us to pay most serious attention to the utilization for this purpose of what has been termed the "watery waste."

For man to overfish and then to wait for the bounty of nature to replenish, or, failing that, to seek new fishing grounds, is, it seems to me, an act to be put in the same category with the doings of nomadic peoples wandering from place to place in search of pastures. Hereafter, streams, rivers, lakes, and seas will have, so to speak, to be pushed to a more efficient degree of cultivation and made to yield their utmost for us. It is perhaps superfluous for me to state this before an audience in America, for I think all candid persons will admit that the United States, with her Bureau of Fisheries, is leading other nations in bold scientific attempts in this direction.

Nor is it simply from the utilitarian standpoint that more attention is likely to be paid in future to the cultivation of aquatic organisms. Far be it from me to depreciate in any way beautiful modern laboratory technique, but I think all will agree the time is now gone by when science considered that when the morphology of an animal has been made out in the laboratory all that is worth knowing about it has been exhausted. We have been apt to forget that animals are living entities and not simply a collection of dead tissues. But we are now beginning to realize that in order to arrive at the proper understanding of biological phenomena we must, in addition to laboratory methods, observe living animals in their natural environment or study them by subjecting them to accurate scientific experiments. To show the efficiency and intricate nature of the new methods, I need only refer to the important results obtained by Professor Ewart, of Edinburgh. And America has also already started a zoological experimental farm, under the able directorship of Professor

---

[a] Read before the International Congress of Arts and Sciences, held at the Louisiana Purchase Exposition, St. Louis, Mo., August 21–25, 1904.

Davenport. From this standpoint the cultivation of various organisms becomes an important and necessary aid to scientific researches, and it is partly for this reason that I venture to call your attention to some of the more successful of culture methods practiced in Japan.

Japan, I need hardly remind you, consists of an immense number of islands, large and small. In proportion to its area, which is nearly 160,000 square miles, its coast line is immense, being, roughly speaking, 20,000 miles. This is broken up into bays, estuaries, inlets, and straits of all sorts and shapes, with an unusually rich fauna of marine organisms everywhere. In addition, the country is dotted with lakes and smaller bodies of fresh water. Put these natural conditions together with the facts that the population, in some districts at least, has been extremely dense, and that until within comparatively recent times hardly any animal flesh was taken as food, and even at the present day the principal food of the general mass of people consists of vegetables and fish—it would be strange indeed if the cultivation of some aquatic organisms had not developed under these circumstances. And such is actually the case. For instance, the oyster culture of Hiroshima and the algæ culture of Tokyo Bay are well-known industries which have been carried on for hundreds of years. Within recent times there has been a development of a number of such enterprises, some of which are interesting even from the purely scientific standpoint. It is my intention to call your attention to the more important of these culture methods, giving preference to those which are peculiar to Japan, and which might be interesting not only from the economic aspect but as a means of scientific investigation.

## THE SNAPPING TURTLE, OR SOFT-SHELL TORTOISE, "SUPPON."

*Trionyx japonicus* Schlegel.

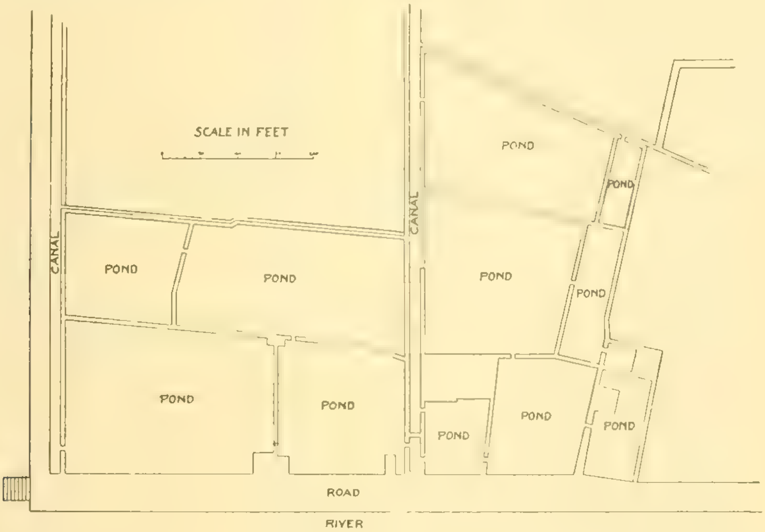
The place occupied among gastronomical delicacies by the diamond-back terrapin in America and by the green turtle in England is taken by the "suppon," or the snapping turtle, in Japan. The three are equally esteemed and equally high priced, but the Japanese epicure has this advantage over his brothers of other lands—he has no longer any fear of having the supply of the luscious reptile exhausted. This desirable condition is owing to the successful efforts of a Mr. Hattori, who has spared no pains to bring his turtle farms to a high pitch of perfection and is able to turn out tens of thousands of these reptiles every year. As his are, so far as I am aware, the only turtle farms in the world which are highly successful, a description of his establishment and methods will, I think, prove interesting and serve as a guide to those who may have similar undertakings in view. In passing I may remark that I have known Mr. Hattori these twenty years and have spent a number of summers on his original farm, collecting, with his kind consent, ample materials for my studies on the development of Chelonia. In return, Mr. Hattori is kind enough to say some of the facts and suggestions I have been able to give him, based on my embryological studies, have been of service in carrying out improvements.

The Hattori family has lived a long time in Fukagawa, a suburb of Tokyo, which lies on the "Surrey" side of the Sumida River, and which, having been originally reclaimed from the sea, is low and full of lumber ponds[a] and until recently of paddy fields. The occupation of the family was that of collecting and selling river fishes such as the carp, the eel, and the crucian carp, and of raising gold-fishes, in addition to the ordinary farmer's work. As far back as in the forties of the last century, the high price commanded by the "suppon" seems to have suggested to the father and the uncle of the present Hattori the desirability of cultivating it, and this idea, once started, seems never to have been lost sight of, although lying in abeyance for a long time.

---

[a] Ponds in which lumber is kept soaked in water.

In 1866 the first large turtle was caught, and from then on additions were made by purchase from time to time, so that in 1868 there were fifteen, and by 1874 the number reached fifty, which were all very healthy, with a good admixture of males and females. In 1875 these were placed in a small pond of 36 tsubos[a], with an island in the center which was intended for the turtles to lay eggs on. They, however, seemed to prefer for this purpose the space between the water edge and the outer inclosure; hence, to suit the tastes of the reptile, the pond was hastily modified into a form very much like the one in use at the present day. That year over one hundred young were hatched, but, unfortunately, they were allowed to enter the pond in which the adults lived, and all but twenty-three of them were devoured, making it evident that some means were necessary to protect them from their unnatural parents. Thus was gradually evolved the present system of cultivation.



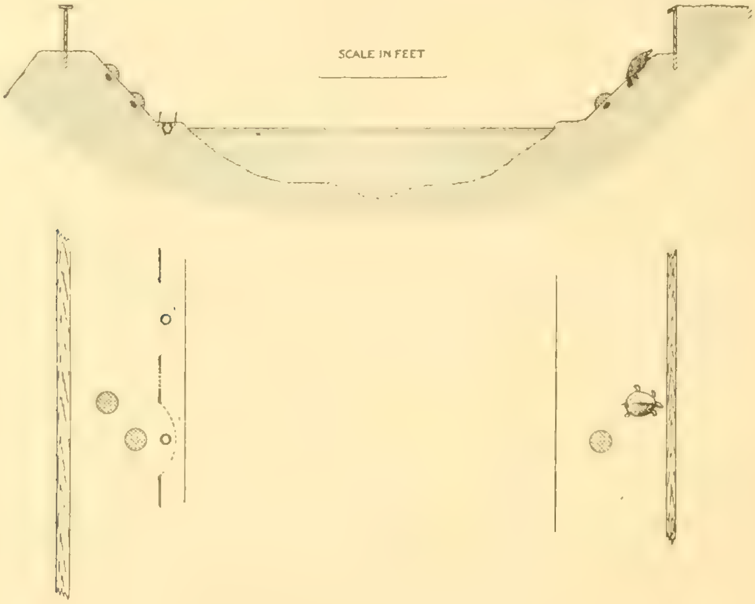
CUT 1.—Plan of a turtle farm.

In general appearance a turtle farm is at a first glance nothing but a number of rectangular ponds, large and small, the large ones having a size of several thousand tsubos. The ponds are undergoing constant modification, being united or separated just as need arises, so that their number may vary considerably at different times. Cut 1 gives the plan of the Hattori turtle farm at Fukagawa as at present laid out. There pass through the farm two small canals which communicate on the one hand with the river across the road, and on the other with the ponds, so that the water can be drawn into, or emptied from, each of them at will.

---

[a] One tsubo, an area 6 feet square, is the unit in the measurement of small land surfaces.

All the ponds, whether large or small, are constructed very much on the same plan. They are limited on their four sides by plank walls, the top of which may either be on the level of the ground (see the right side of the section, cut 2) or may be more than a foot above the ground when two ponds are contiguous (the left side, cut 2). In either case the plank wall has a cross plank of some width at right angles to it on its top, and is also buried some inches in the ground. The former arrangement is, of course, to prevent the tortoises from climbing over the wall, and the latter to prevent them from digging holes in the ground and making their escape in that way, while at the same time it serves to exclude the moles. On the inner side of the plank wall there is more or less of a level space, and then a downward incline of 3 or 4 feet. At the foot of this incline and directly around the water's edge there is another level space which enables people to walk around the pond. From the edge of the water the bottom of the pond deepens rather rapidly for a space of some 3 feet and there reaches the general level of the bottom, which is about 2 feet below the level of the water. The greatest depth of a pond is about 3 feet and is always toward the water gate by which the pond communicates with the canals. The bottom is of soft, dark mud, several inches thick, into which the tortoises are able to retire to pass the winter.



CUT. 2.—Section and plan of a turtle pond.

On a turtle farm one or more of the ponds is always reserved for large breeding individuals, or "parents," as they are called. The just-hatched young or the first-year ones must have ponds of their own, as must also the second-year ones; those of the third, fourth, and fifth years may be more or less mixed.

In order to give a connected account of the raising of tortoises, we might begin with a description of the pond for large breeding individuals, or "parents," and with an account of egg-laying and hatching.

The "parents' ponds" does not differ in any remarkable way from the general plan of a pond given above. Usually one of the largest ponds is chosen, and it can be distinguished from the others, because one or two of its slopes are usually kept up very carefully, while the other slopes or those of other ponds are apt to be worn by rain and wind and to become rugged. These well-kept slopes are invariably on the warmer sides, where the sun pours down its midsummer rays longest, and are carefully worked over in the spring so that the tortoises will find it easy to dig holes in them. In the breeding season these sides are seen to be covered with wire baskets which mark the places where the eggs have been laid.

Copulation takes place on the surface of the water in the spring. Egg deposition begins in the last part of May and continues up to the middle of August. Each female lays during that time two to four deposits, the number differing with individuals and with years.[a] The process of egg deposition is very interesting. A female comes out of the water and wanders about a little while on the banks of the pond in search of a suitable locality in which to deposit eggs. Having finally chosen a spot, with her head directed up the bank she firmly implants her outstretched fore feet on the earth, and during the whole operation never moves these. The process of egg deposition, which takes altogether about twenty minutes, may be divided into three portions occupying about the same length of time, namely: (1) digging a hole, (2) dropping eggs in it, and (3) closing the hole. The digging of the hole is done entirely with the hind legs. Each with its nails outstretched is moved firmly from side to side—that is, the right foot from right to left and the left from left to right, and the two are worked in a regular alternation, while the body is swayed a little from side to side, accompanying the motion of the legs. The force put in the lateral pressure of the feet is so strong that the earth that has been dug out is sometimes thrown off to a distance of 10 feet or more, although the largest part of it is heaped up around the hole. Digging seems to be continued as long as there is any earth within the reach of the legs to be brought up. The result is a squarish hole with the angles rounded off, and although its size differs with the size of the female, it is generally about 3 to 4 inches across at the entrance, with the depth and width inside about 4 inches or more. When digging is finished eggs are dropped from the cloaca into the hole, which naturally lies just below it. The eggs are heaped up without any order, but, there being no chalazæ, the yolk is able to rotate in any direction, and the blastoderm, having the least specific gravity, always occupies the highest spot of the yolk in whatever position the egg may happen to be dropped. The eggs are generally spherical in shape, although sometimes more or less oblate. Their diameter is in the neighborhood of 20 millimeters, the largest being as large as 24 millimeters, the others smaller according to the size of the females. The number of eggs in one deposit varies from 17 or 18 up to 28 or more, the smaller individuals producing the smaller number.

---

[a] See my notes: "How many times does the snapping turtle lay eggs in one season?" Zoological Magazine, Vol. VII, p. 143, 1895. Tokyo.

When the eggs have all been deposited, the turtle's legs are again put in requisition, this time to fill up the hole, which is done by alternate motions as before. The earth about the hole is used at first, but search is made for more loose earth for a little distance, as far around as the legs can reach with a slight motion of the body either to the right or left without moving the front legs. Toward the end of the process the loose earth is trampled down. When the hole is well filled up to the level of the ground, the turtle turns around and goes immediately down into the water, not casting even one backward glance.

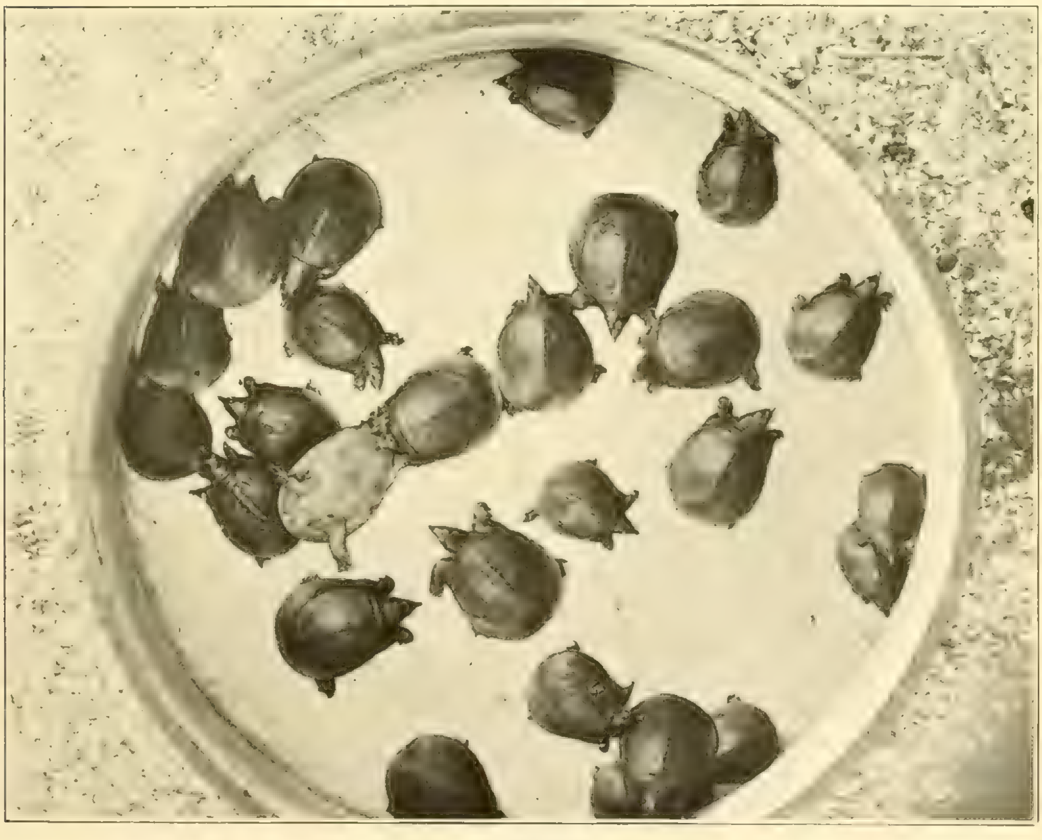
I have noticed an interesting contrast between the behavior of *Trionyx* and of *Clemmys* during the egg deposition. If one wants to watch a *Trionyx* depositing eggs, one has to crawl on all fours behind the plank wall of the pond and peep through a hole, being careful not to show himself. The moment the snapping turtle sees anyone, it stops in whatever part of the egg-laying process it may be engaged and plunges straight into the water. Utterly different is the behavior of *Clemmys*. When once it begins the process of egg-laying it is never deterred from carrying it out, no matter how near or how boldly one may approach. Whenever I watched a *Clemmys* working away in the direct midsummer rays with its carapace all dried up and with its eyes alone moist, I could not helping comparing it to a slave of duty fulfilling his fate with tears in his eyes. What causes such a difference of behavior in the two species? What is its significance? What difference in the nervous system corresponds to it?

The traces of a spot where the snapping turtle has laid eggs are (1) the two marks made by the forepaws holding on to the earth during the whole operation, and (2) a disturbed place some distance back of the line of the forepaws where the hole has been made. The three marks are at the angles of a triangle. I have noticed a very interesting fact in regard to these traces. When a young female is depositing her first eggs, she is very clumsy, the hole being badly made and the filling in of it very imperfect, so that often a part of it remains open. Old females are extremely neat in their doings, and one can determine at once the age and size of the female by the skill displayed and by the distance between the three marks of egg deposition. This shows that although the elaborate actions necessary in egg laying must be, in the main, due to instinct, each individual has to add its own experience to the inherited impulses and is able thus only to accomplish the desired end with perfection.

In Hattori's farm a person goes around the "parents' pond" once a day or so and covers up with wire baskets all the new deposits made since the last visit (pl. II, fig. 1). Each basket may be marked with the date if necessary. This covering serves a two-fold purpose—the obvious one of marking the place, and in addition that of keeping other females from digging in the same spot. When hundreds, or even thousands, of these baskets are seen along the bank of a "parents' pond," it is a sight to gladden the heart of an embryologist, to say nothing of that of the proprietor.

The hatching of the eggs takes, on an average, sixty days. The time may be considerably shortened or lengthened, according to whether the summer is hot and the sun pours down its strong rays day after day, or whether there is much rain and the heat not great. It may become less than forty days or more than eighty days. By the time the last deposits of eggs are made in the middle of August, the early ones,

1. EGG DEPOSITS OF TRIONYX COVERED WITH WIRE BASKETS.



2. SECOND-YEAR YOUNG OF TRIONYX.

Reduced ½

which were laid in May or June, are ready to hatch; and inasmuch as if small tortoises that have just emerged from the eggs are allowed to get into the "parents' pond" they are devoured by their unnatural fathers and mothers, a special arrangement has now to be put up to prevent this. Figure 1, plate III, and the left side of the plan in cut 2 are intended to show this arrangement. Long planks about 8 inches wide are put up lengthwise around the edge of the pond, leaving perhaps 1 foot margin between them and the water. Two successive planks are not placed contiguous, but a space of about 3 feet is left between every two, and closed by a bamboo screen put up in the shape of an arc of a circle, with its convexity toward the pond. Thus the slope or the bank where the eggs have been deposited is completely cut off from the pond itself. In the center of every pocket-like arched space made by a bamboo screen an earthenware jar is placed with its top on the level of the ground, and some water is put in it. This elaborate arrangement is for the reception of the young tortoises, which, as soon as they break through the egg shells—those belonging to the same deposit generally coming out at the same time—crawl up to the surface of the ground by a hole or holes made by themselves, and go straight down the incline toward the pond, as naturally as the duckling takes to the water. They are stopped, however, in their downward hydrotaxic course by the planks put up, as stated before, around the pond, and they crawl along the length of the planks and sooner or later drop into the jars placed in the recesses between every two planks. A man going around once or twice a day can easily collect from these jars all the young hatched since the last visit.

The young just hatched are put in a pond or ponds by themselves and given finely chopped meat of a fish like the pilchard. This is continued through September. In October *Trionyx* ceases to take food, and finally burrows into the muddy bottom of the pond to hibernate, coming out only in April or May. The young are called the first-year ones until they come out of their winter sleep, when they are called the second-year young. At first the same kind of food is given these as that given to the first-year young, but gradually this may be replaced by that given to older individuals, namely, any fish meat or crushed bivalves, etc. Figure 2, plate II, shows a lot of the second-year young in August. From the third to the fifth year, inclusive, the young need not be kept in ponds strictly according to age, but may be more or less mixed, if necessary. The young of these years are also the best and most delicate for eating and are the ones most sold in the market. In the sixth year they reach maturity and may begin to deposit eggs, although not fully vigorous till two or three years later. How old these snapping turtles live to be is not known. Those 1 foot and more in length of carapace must be many years old. The following table gives the average size of the carapace and the weight of the young:

| Age. | Length in centimeters. | Breadth in centimeters. | Weight in grams. |
|---|---|---|---|
| Just hatched | 2.7 | 2.5 | ........ |
| First year | 4.5 | 4.2 | 23 |
| Second year | 10.5 | 8.8 | 169 |
| Third year | 12.5 | 10.5 | 300 |
| Fourth year | 16.0 | 13.5 | 563 |
| Fifth year | 17.5 | 15.1 | 750 |

One of the most important questions in turtle farming is that of food supply. The profit depends largely on whether a constant supply of healthful food can be obtained cheaply and abundantly. In the Hattori farm chief dependence in this respect is laid on the "shiofuki" shell (*Mactra veneriformis* Deshayes) which occurs in enormous quantities in the Bay of Tokyo. These shells are crushed under a heavy millstone rolled in a long groove in which they are placed, as shown in figure 2, plate III. Other kinds of food given are any dried fish scraps, silkworm pupæ, boiled wheat grains, etc.

A curious part of the ecological relations of a turtle pond is this: It would be supposed that putting other animals in the same pond with the snapping turtles would be detrimental to the welfare of the latter, but experience has proved just the contrary. It is now found best to put such fishes as carp and eels in the same ponds with the turtles. The reason, I am told, is that these fishes stir up mud and keep the water of the pond always turbid, and this is essential to the well-being of the turtles, as is proved when the messmates are taken out of the pond. Dirt and mud then settling down, and the water becoming clear and transparent, the turtles, which are extremely timid, will not go about searching for food, and thus very undesirable results are brought about.

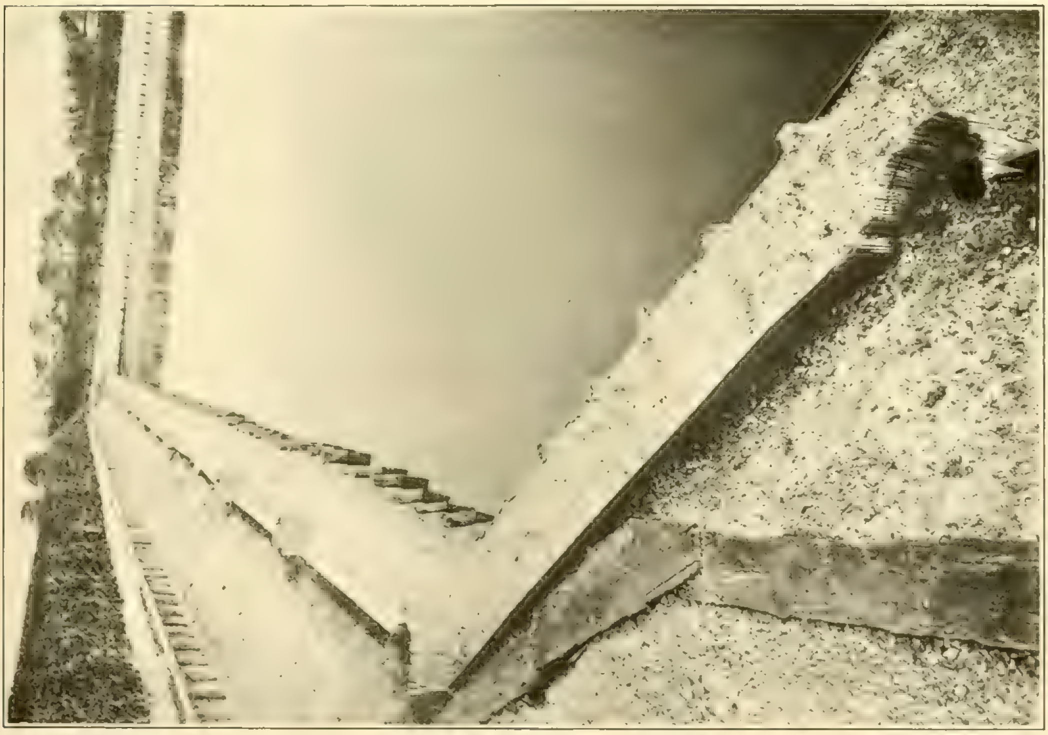
The business of turtle raising has thrived well. When I first became acquainted with the turtle farm, now over twenty years ago, it was a small affair with only a few small ponds, and the eggs hatched out in one year were, all told, not much over 1,000. Now the enterprise embraces three establishments: (1) The original farm at Fukagawa, Tokyo, now enlarged to 7 acres; (2) the large farm at Maisaka, near Hamamatsu, province of Totomi, over 25 acres, whither the main part of the business has been transferred; and (3) the second farm in Fukagawa, about 2 acres in extent. These three establishments together will yield this year (1904) about 4,100 egg-deposits, which means 82,000 eggs, counting 20 eggs to a deposit on an average. Probably 70,000 young will be hatched from these, and deducting 10 per cent loss before the third year, there will be about 60,000 "suppon" ready for the market in three years. The turtles sold in a year in Osaka, Tokyo, Nagoya, and a few other towns weigh about 2,000 kwan (=16,500 pounds), and are worth about 6.50 to 7.50 yen (1 yen=$0.50) per kwan.

There are several minor turtle farms besides those mentioned above, but as they are all modeled after those under Mr. Hattori's management, they need not be described further.

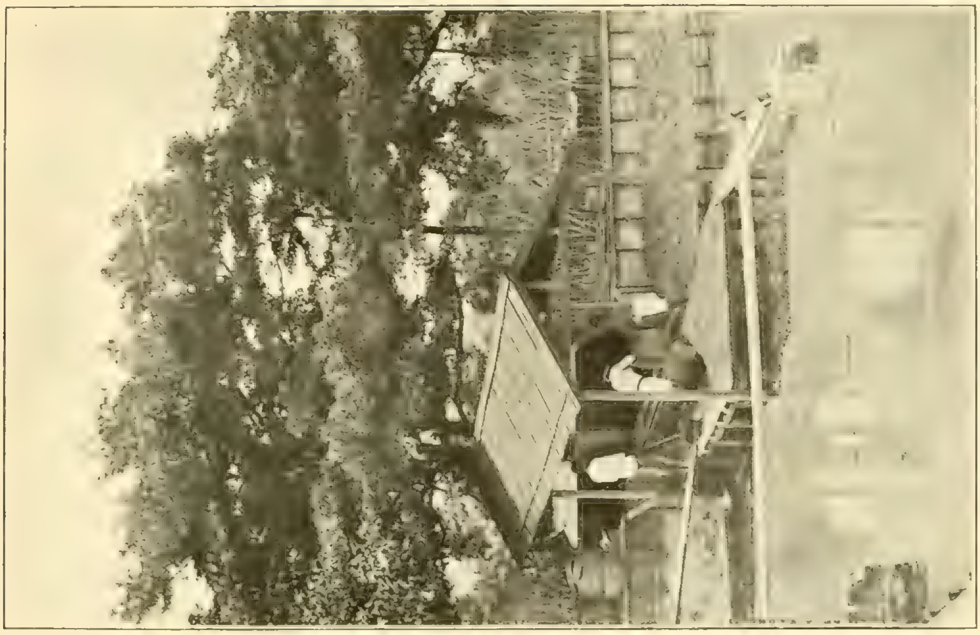
## THE GOLD-FISH.

### *Carassius auratus* Linnæus.

The gold-fish is the characteristically oriental domesticated fish. Its beautiful bright coloration and graceful form, with long, flowing fins, appeal most strongly to one's sense of the beautiful. It also is intensely interesting from the scientific standpoint, and proves a source of endless surprises to the biologist, for it is a plastic material with which skillful breeding can, within certain limits, do almost anything. Our gold-fish breeder seems to have understood the principle of "breeding to a point" to perfection, and I have often been interested in hearing some



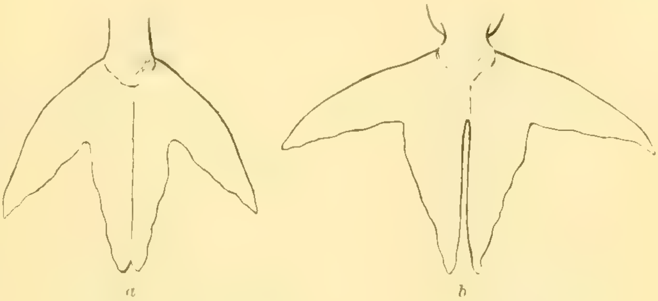
1. ARRANGEMENT FOR COLLECTING YOUNG TURTLES JUST HATCHED.



2. CRUSHING SHELLS FOR FOOD OF TURTLES.

of them talk in a way which reminded me of passages in the "Origin of the Species" or other Darwinian writings. This must be considered remarkable, for these breeders are, as a general thing, without much education, and have obtained all their knowledge from the practical handling of the fish.

The history of the gold-fish is lost in obscurity. Like so many things in Japan, it seems to be an importation from China. There is a record that about four hundred years ago—that is, about the year 1500—some goldfish were brought from China to Sakai, a town near Osaka. The breed then brought in is said to be that now known as the "wakin." There must also have been several later importations and the Japanese must have improved vastly on the original forms, as in so many other cases of things introduced from foreign countries. Several varieties have thus resulted, but before proceeding to describe these I may say a few words about gold-fish in general. A characteristic of the gold-fish, no matter of what variety, is that the black pigment with which the body is uniformly colored when first hatched from the egg disappears in a year or so and gives place to bright colors, which are of various shades between carmine and vermilion red and which may be either spread all over the body or variegated with white in various degrees. A fish that is entirely white fetches no price in the market, and is mercilessly eliminated in the first year. A fish with the white body variegated with red around the lips and on the opercula and all the fins is considered to have the best coloration. The dorsal fin is either single or absent. The tail may remain simple, as in ordinary fishes, but should best split open and spread out horizontally, when it is therefore three-lobed (cut 3, *a*), but quite as frequently it may be split in the median lines, when it is four-lobed (cut 3, *b*). The anal fin may also very often split open and become paired.[a]



Cut 3.—Diagram of the tail of a gold-fish. *a*, Three-lobed; *b*, four-lobed.

There are five well-established varieties of the gold-fish in Japan, and in addition one or two which have not become so common as yet. I will go over these varieties briefly (compare pls. IV and V):

1. The "wakin" (literally "Japanese gold-fish"). This has a shape nearest the normal form of a fish. The body is slender and long, closely resembling that of the common crucian carp. The tail may be single, vertical, and normal, but should, to be a good form, split open and become either three-lobed or four-lobed. This may, in short, be characterized as the bright-colored variety of the common *Carassius auratus* with or without the modified tail.

2. The "ryukin" (literally "Loochoo" gold-fish), also called the "Nagasaki". The first name may possibly denote whence the variety came originally. The body

---

[a] For further details see S. Watase: "On the Caudal and Anal Fins of Goldfishes." Journal Science College, Vol. I, p. 247, Pl. XVIII–XX.

is strikingly shortened—this being one of the points to which the variety was bred—and has a rounded, bulged-out abdomen. The tail and all the fins are long and flowing, the former being as long as or even longer than the body. This, in my opinion, is the most beautiful breed. A "ryukin" 2 or 3 years old, slowly swimming with its long, flowing, graceful fins and tail, full of quiet dignity, I can liken to nothing so much as to Japanese court ladies of olden times, dressed in long robes and walking with quiet grace and dignity.

3. The "ranchu," also called "maruko" (literally, round fish), "shishigashira" (literally, lion-headed), and sometimes "Corean goldfish." This is distinguished by its rather broad head, its extremely short, almost globular body, the short tail, and the absence of the dorsal fin. Some individuals of this variety develop in the second year, or at the latest in the third year, a number of peculiar wart-like protuberances all over the head, making it look as if it had a low coxcomb or some skin disease. Such fish are called the "shishigashira," or "lion-headed." This variety is seen often swimming upside down, a fact with which the absence of the dorsal fin probably has something to do.

4. The "oranda-shishigashira" (literally, Dutch lion-headed). The adjective Dutch is known to have nothing to do with the place of origin of the fish, but was attached to the name to denote something novel. This variety was produced in Osaka in the forties of the last century by crossing the "ryukin" with the "ranchu." Therefore, it possesses a body more or less like that of the "ryukin" with the dorsal fin, but from the second year or thereabouts the head begins to develop the wart-like protuberances described under the "ranchu."[a] When fully developed, this breed is, to my mind at least, anything but beautiful. It is cultivated near Kyoto or Osaka, while the "ryukin" is reared most in Tokyo.

The above four breeds are common and can be seen in almost any gold-fish seller's. There are some other rarer or newer varieties:

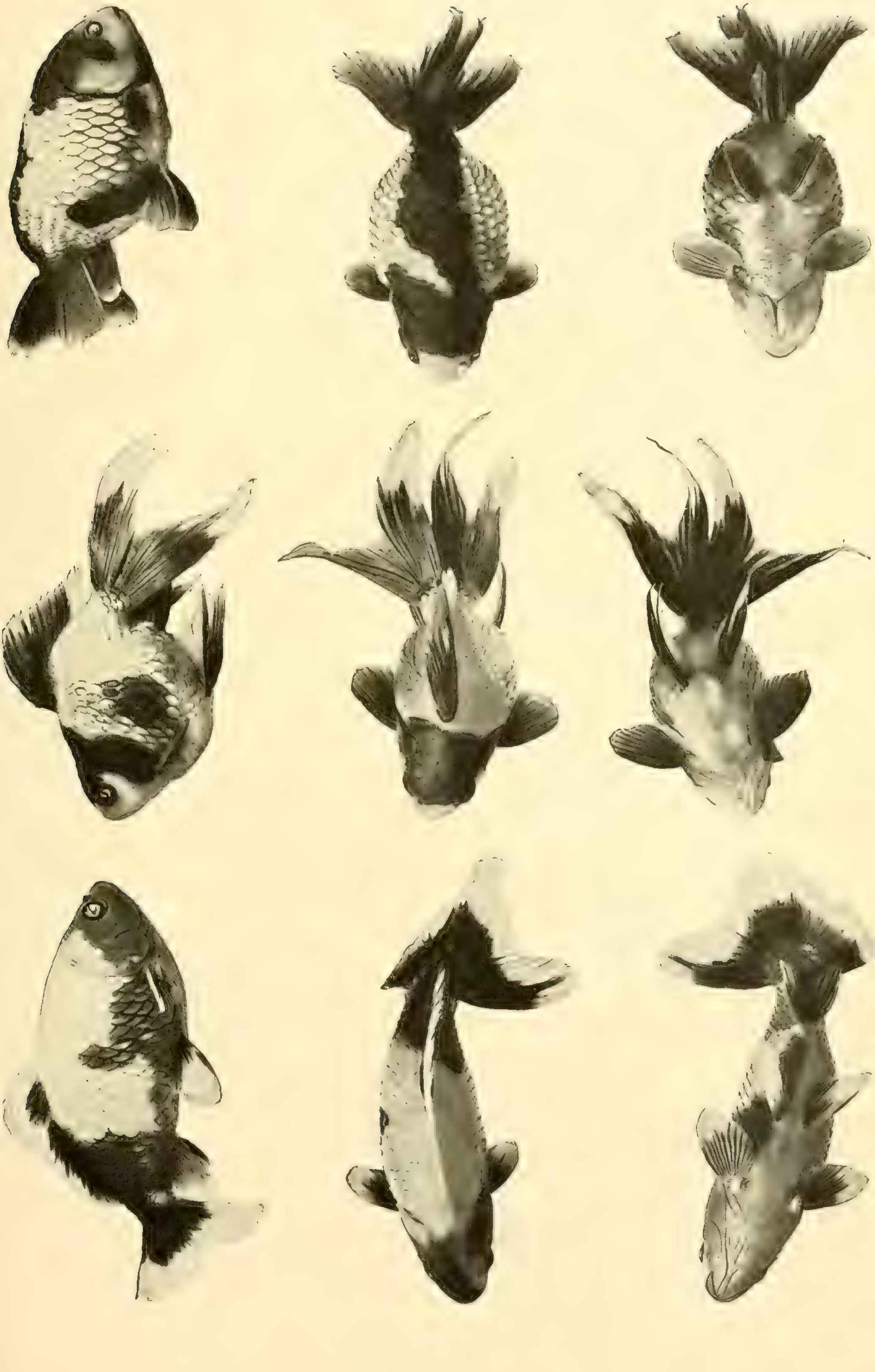
5. The "shukin." This is a breed only recently produced by my friend, Mr. Akiyama, a skilful gold-fish breeder of Tokyo, and also produced independently in Osaka. It was obtained by crossing the "oranda-shishigashira" with the "ranchu." It is "lion-headed"—that is, has warts on the head—has the globular body of the "ranchu" without any dorsal fin, but it has a long flowing tail. It may be characterized as a long-tailed variety of the "ranchu."

6. The "demé" (literally "protruding eyes" or "telescope fish"). Contrary to what is stated in many American and European books, the telescope fish is only a recent introduction into Japan. In fact, it was brought to Japan at the end of the late Japan-China war (1894–95). As is well known, in this variety the large eyeballs have started out of the skull and protrude sideways from the head, which thus somewhat resembles (although only superficially) that of the hammer-headed shark. The body is short; the color is yellowish, or at least not usually bright red, and often has black spots or irregular black patches scattered over the body. It should be stated that the first-year young have the eyes in the normal position, the protrusion occurring gradually in the course of growth and not through any artificial devices. These

---

[a] I am sorry that these are not very well brought out in the accompanying photographs. They are seen better in plate VI.

PLATE IV.

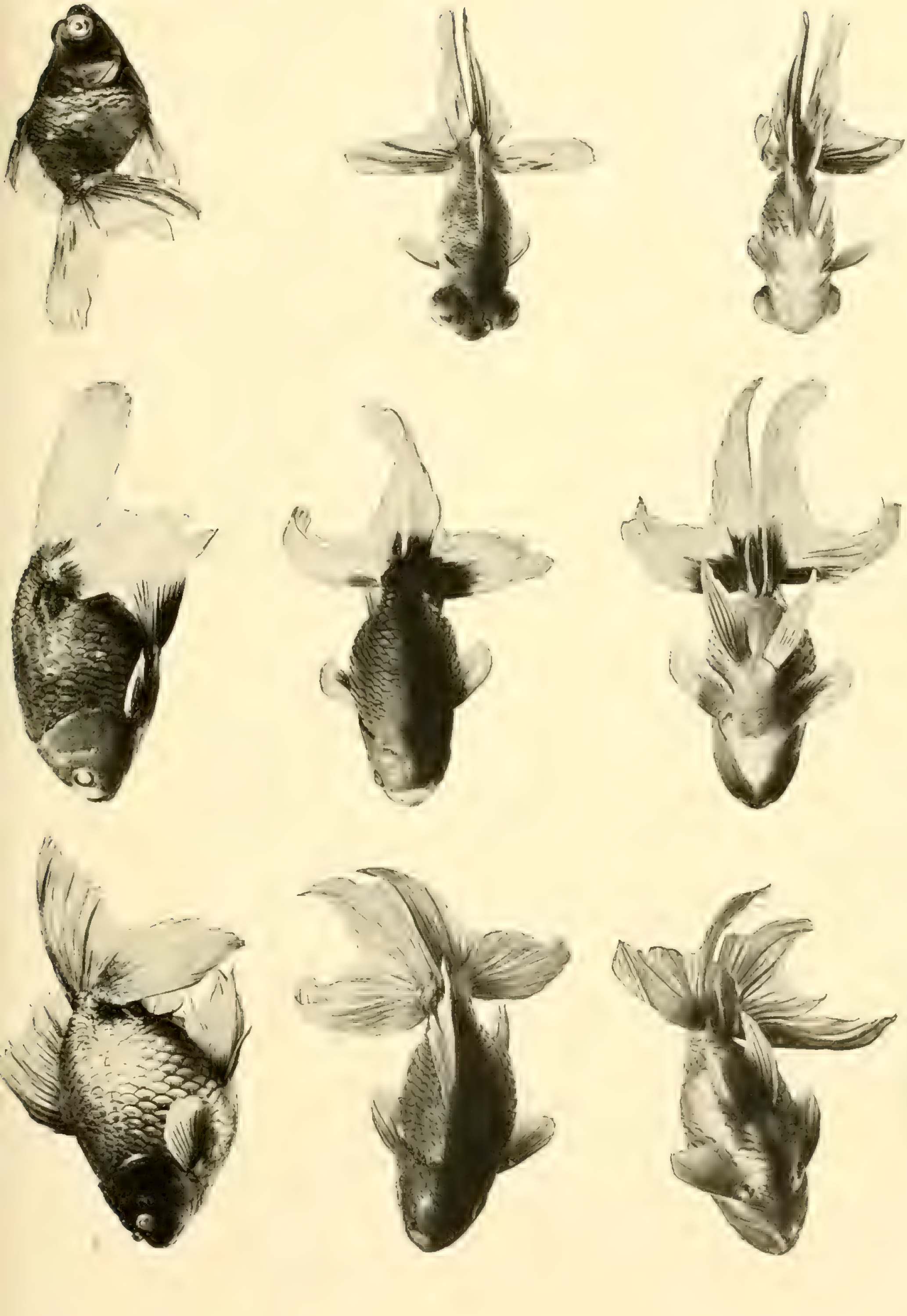


VARIETIES OF GOLD-FISH (LATERAL, DORSAL, AND VENTRAL VIEWS).

Ranchu.

Ryukin.

Wakin.

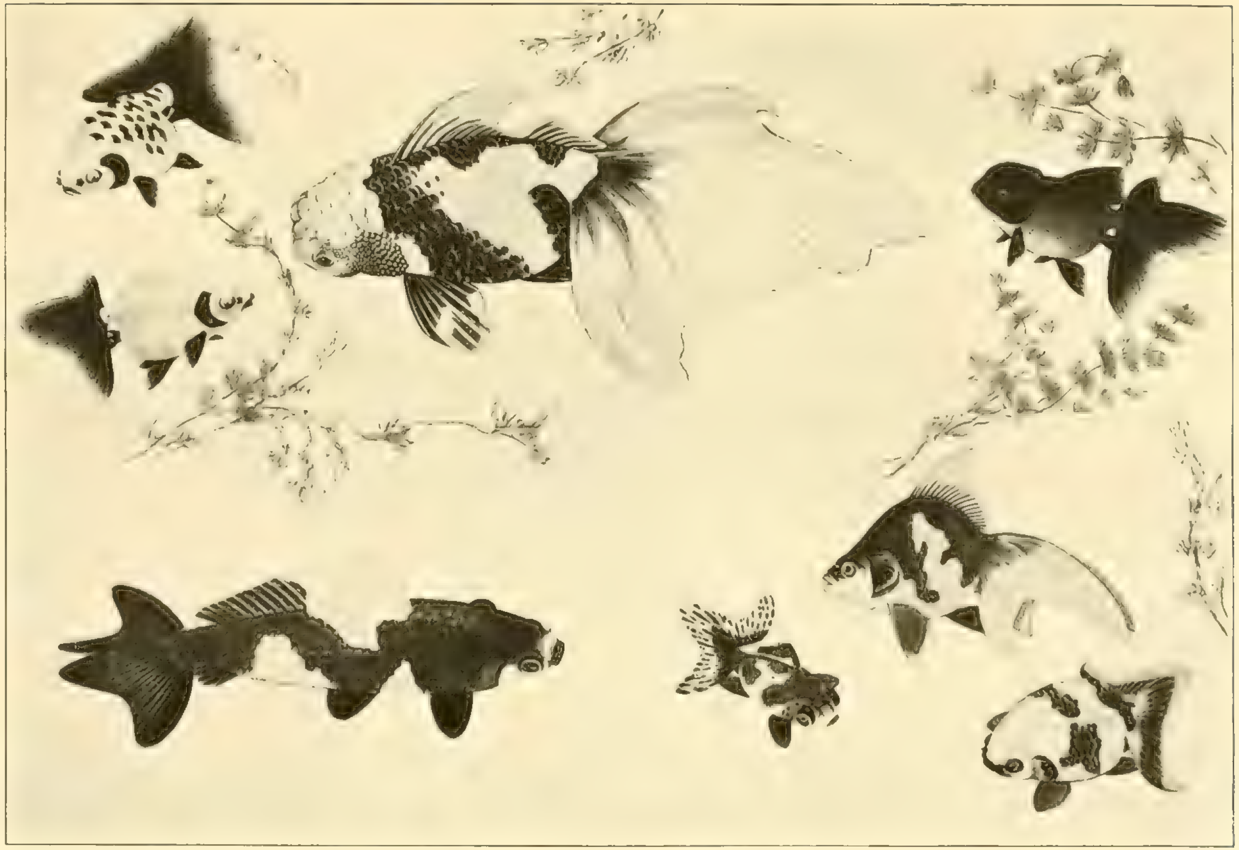


Demé.

Shukin.

Oranda shishigashira.

VARIETIES OF GOLD-FISH (LATERAL, DORSAL, AND VENTRAL VIEWS).

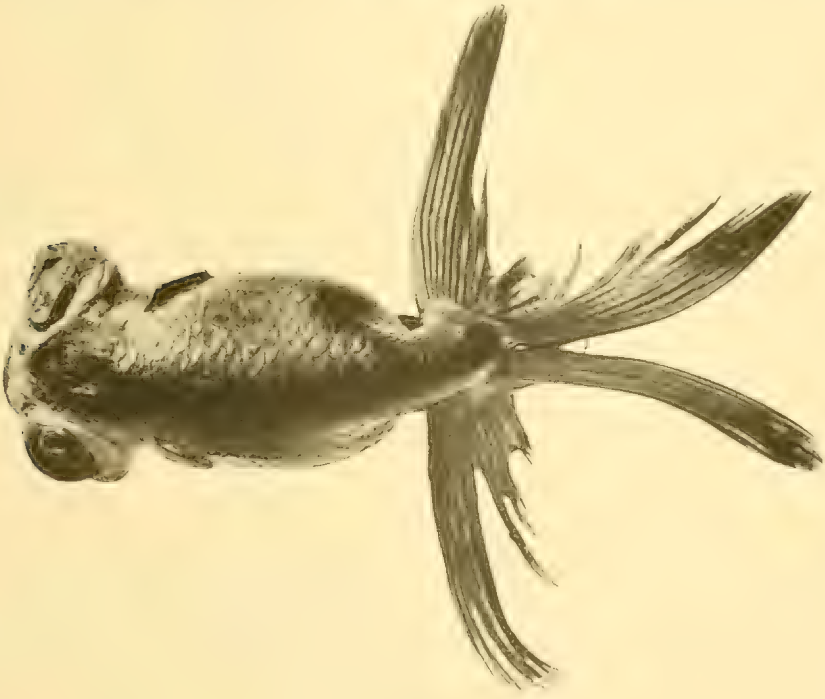


VARIETIES OF GOLD-FISH (FROM JAPANESE PAINTINGS).

Lower left, wakin; lower right (group of three), demé, ryukin, ranchu; upper left (two), ranchu; upper middle and right, oranda shishigashira.

fish, when fully grown, are apt to strike their eyes against the sides of the ponds, tubs, etc., in which they are kept, and to injure them so that they often become blind. In nature, therefore, such a protuding eye must be a distinct disadvantage, and would never have been produced except by artificial selection.

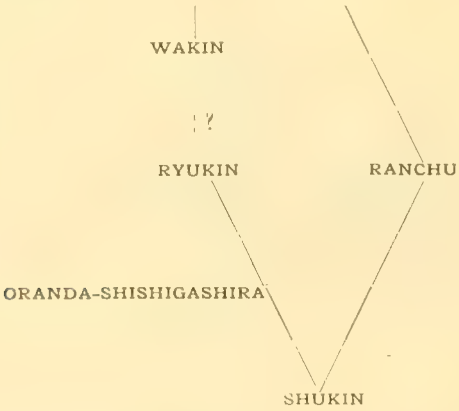
7. The "demé-ranchu" (cut 4). This variety is not yet naturalized in Japan, having been imported from China only within the last two or three years. Of all the extraordinary and odd-looking fishes, it certainly is far in the lead in many respects, and is interesting as showing how far man can proceed in modifying nature. It is a telescope-fish with a short globular body resembling the "ranchu," and, like it, without the dorsal fin. The eyes have assumed a most extraordinary position. The ordinary telescope-fish is odd enough, with the eyes protruding, but in this variety dislocation has gone one step further. The eyes have not only started out of the head, but have turned upward 90 degrees and have their pupils looking straight skyward. For this reason I should be inclined to call this "astronomical telescope-fish." As a fish, it is so monstrous that it gives one almost uncomfortable feelings.



CUT 4.—The "demé-ranchu."

It is an interesting fact that in the forms without any dorsal fin, many young show more or less traces of that fin. Sometimes there may be only the first spine, at other times only a few spines, at still others a little bit of a fin, etc., showing that the fin must have been bred off comparatively recently.

There can be no doubt that of these varieties the "wakin" is the most primitive, as can be seen from its shape, as well as from the fact that it is much hardier than the others, and therefore easier to rear. The "ryukin" is next the "wakin" in its nearness to the original *Carassius.* It is still like an ordinary fish, although its shortened body and long flowing fins show that changes have already gone very far. The "ranchu" seems further removed from the original type, as its globular body and the absence of the dorsal fin well testify. The relations that these three varieties hold to one another are involved in obscurity. Some think that the "ryukin" is a cross between the "wakin" and the "ranchu," but I think that this can hardly be so. I am inclined to think that the "ryukin" must have been bred from ancestors somewhat like the "wakin" by careful selection, and that the "ranchu" is the offshoot of another branch which must have separated from the "wakin" stem very early. The cross between the "ryukin" and the "ranchu" is the "oranda-shishigashira," and this crossed again with the "ranchu" is the "shukin." An interesting fact is that in the first cross both the dorsal and the tail fins are long, but in the second cross the dorsal fin is lost, while the tail is not only retained but remains long. Expressed in a diagram, the supposed genealogy would be as follows:



The gold-fish is very common in Japan and more or less reared in all parts, but the main centers of cultivation are Tokyo, Osaka, and Koriyama (a small town near Nara, where almost every household engages in this business). Each of these places has its own peculiarities in the method of raising, but the differences are, on the whole, in minor details only. In Tokyo gold-fish breeders are all located in low-lying parts of the city, where ponds, a sine qua non of this business, can be easily made.

One establishment is very much like another, the principal differences being in the number and size of ponds. Figure 2, plate I, gives a view of a typical one. There is always a number of shallow ponds, as shown in the foreground of the photograph. (In the particular place where this photograph was taken I think I counted ten.) Fortunately, water had been drained off the nearest pond and one can see its construction and depth without further explanation. The shallow dishes slung by three strings from bamboo poles stuck in the muddy bottom of the pond, seen in the photograph, are the dishes in which food is given to the gold-fish. Besides these shallow ponds there is always a large number of shallow square cement basins of various sizes, some as small as 3 feet by 3, others as large as 12 feet by 12, with intermediate sizes of all sorts. (In the figure, a man with a hand-net is standing in the midst of these basins.) They are very shallow, being not more than a few inches deep, can be easily drained or filled, and can be shaded or exposed to the sun at will. In the figure, the wire-gauze coverings are seen half lifted up, to the right of the man with a hand net. To the left of these basins there is the main house with the thatched roof, where the proprietor lives with his family. Under the rush shade in front of the house there is seen a large number of trays piled up one above another, and also a number of pails for carrying fish about. Under the shade is standing the mistress of the establishment—somewhat out of focus. Farther beyond are two young girls, not clearly seen, sorting some undesirable fish out of a lot of the first yearlings. A man is drawing water from the well with a sweep. A smaller house to the right is the place where fish food is prepared. A visit to such an establishment would delight the hearts of not only children, but grown-up persons who love bright colors and graceful forms, for the ponds are full of brilliantly colored fish of all ages and sizes. Here are huge fourth-year "wakin," there graceful second-year "ryukin," off there fine "ranchu". Ornamental little carps, little tortoises, and tiny fish called "medaka" (*Aplocheilus latipes*) are also generally found in the gold-fish breeders' establishments.

The process of rearing gold-fish is in its main outline as follows: Large gold-fish that are 3 or 4 years old, with good forms and healthy in every respect, are carefully selected for the purpose of breeding. This takes place any time between the last part of March and the middle of June, the usual time being in April and May. At this season the color of the fish becomes more brilliant than ever, and small, low warts that can barely be felt with one's finger are said to be produced on the opercula of the male. Both sexes crowd together, causing great commotion in ponds in which they are kept. Plenty of a waterweed ("kingyomo," or "matsumo," *Ceratophyllum demersum* Linnæus), or bundles of fine roots of the willow tree are placed in the pond, and on them the gold-fish lay their eggs. It is an interesting fact that gold-fish breeders are able to control, within a certain limit, the time of deposition of eggs. If the fish are given plenty of food beforehand and then the water of the pond in which they are kept is renewed, or if they are placed in another pond, they will deposit eggs in a day or two. On the contrary, if they are underfed and kept in the same stagnant water, they will desist from depositing eggs sometimes altogether.

The eggs take eight to nine days to hatch. The young for the first few days are given the yolk of hen's eggs, boiled. Food is usually given them on shallow earthenware plates, slung by three strings from a bamboo pole (fig. 2, pl. I), for the youngest these plates being kept at the depth of a little over 1 inch below the surface of the water. For the next two or three weeks the young are given various kinds of fresh-water Copepoda. These the gold-fish breeders prepare beforehand in a separate pond, for they have the knack of producing these water fleas in any quantity they need at any time they like. After Copepoda, succeeds the ordinary food of the gold-fish, such as fresh-water earthworms, boiled cracked wheat, etc. It is essential for the growth and health of the fish that they be kept as warm as possible; hence, the shallow earthenware dishes from which they are fed are kept at first--that is, when the fish are first hatched, and, therefore, in the hot season --only a little over an inch below the surface of the water. With the growth of the young and the approach of the colder weather they are gradually put down lower and lower, until in the winter they are down nearly 10 inches, such a depth being naturally warmer than nearer the very surface of the water.

Among the young fish all sorts and conditions of the body and the fins are found—that is, all forms intermediate between those closely resembling the normal crucian carp with a long slender body, the unsplit tail and anal fins, etc., and those which are extremely modified, as shown in the varietal types described above. If a lot of young contains a large percentage of those with the unsplit tail, it is considered, from the commercial standpoint, a failure, for these latter are only a fraction of the split-tailed in price. In some experiments I have tried it was found that in selecting for breeding the adults which have the split anal fin give, on the whole, better results than those with a single anal. It is needless to say that all undesirable ones are early eliminated.

All the young just hatched are dark in color, the bright colors coming only later. A great deal of experience and skill is needed in making the gold-fish change its color from black to red. If a person who is not an expert tries his hand at raising a lot of young gold-fish he will find to his sorrow that the fish remain black and do not assume bright colors, while those which may be from the very same lot of eggs, but have been under the care of a professional breeder, may have all donned the beautiful hues. The essential points to be attended to in bringing about this change seem to be (1) that the young fish should be given plenty of food, (2) that they should be exposed to the sun's rays and be kept as warm as possible, and (3) that the water of the pond in which the young are kept should be changed occasionally, although sudden transfer from warm to cold water in the middle of the day is to be avoided. The change of color begins in about sixty to eighty days from the time of hatching, and by the middle of August the fish should all have lost the dark pigment and acquired bright colors. I am told a curious fact—that the fish which change their color earliest are apt to be white or variegated white and red, while those that change later are apt to be uniformly red. What can be the significance of such a fact? I am also told that by the middle of August of the second year, all the individuals, however obstinate, change their color. It is worth while determining whether, even if the young are left to themselves and not given the care which they receive at a breeder's, they will change color by the summer of the second year.

White is commercially worthless and is ruthlessly weeded out. It is also said that to improve the brightness of the color, the fish should be somewhat underfed—that is, should be given about 80 per cent of the ordinary feed. In Koriyama they have the trick of bleaching out white spots in the red, by applying some mixture. The result, I think, is not worth much.

I have by no means exhausted the subject of the gold-fish; in fact, I doubt whether anyone can write all the minute details of the art of gold-fish raising. But I think I have said enough to show how full of interest gold-fish breeding is, not only from the commercial or æsthetic point of view, but from the purely scientific standpoint. A most casual glance shows it to be full of problems which have ever attracted the serious attention of biological investigators.

I have just now no available statistics in regard to the output of gold-fish, but the number produced must be millions upon millions. It shows the power of children in the nation, for they are par excellence the customers of these establishments. It is said that in the old régime, even in years when a famine was stalking in the land and hundreds were dying from starvation, there was a tolerable trade in gold-fish, proving the truth of an old proverb: "Crying children and landlords must not be disputed." Landlords are not now tyrannical as of yore, but children have not abated their power in the slightest degree, and that they do not get the moon seems simply to be due to the fact that it involves an impossible feat for their parents.

### THE CARP.

*Cyprinus carpio* Linnæus.

Closely connected in some respects with the culture of the snapping turtle and of the gold-fish is that of the carp. As stated before, the carp is put in the same pond with *Trionyx;* and the raising of the ornamental varieties is generally undertaken by gold-fish breeders. There are several breeds, among which the red carp ("higoi"), the "hokin" (literally "gold-cheeked," with the operculum of the gold or silver color) and the "goshiki-goi" (literally "five-colored," or variegated) are the most common. Travelers in Japan must have noticed in ponds belonging to various temple grounds these ornamental carps, which often reach the enormous size of 2 feet or more, and which children delight in feeding.

The ordinary carp itself has been very extensively cultivated from olden times in Japan in ponds, reservoirs, and various other bodies of water, and the business has been considered profitable, as the fish commands a comparatively high price.

Around or near Tokyo, especially in the district called Fukagawa, there have sprung up within the last twenty years a number of carp-culture establishments. They carry out at the same time and in the same ponds the culture of the eel and of the gray mullet ("ina" or "bora," *Mugil oeur* Forskål), the three fishes going well together and being consumed to a great extent in the city of Tokyo. It is estimated that there are in this small district alone 225 acres devoted to carp culture, producing annually 405,000 pounds of the meat of this fish, valued at 30,000 yen at the wholesale price, and furnishing a large part of the supply for Tokyo and its neighborhood. I ought to add that Mr. Hattori, who is the proprietor of the turtle farm, was largely instrumental in developing the industry in this region.

Some of these establishments are very interesting. Figure 1, plate VII gives a view in one of them—a very large establishment, with an area of 75 acres, and a large number of ponds, the largest of which are about 5 acres in extent.

The carp is reared from the egg in these establishments. In May of every year large adult individuals are carefully selected for breeding, and, as in the case of gold-fish, eggs are made to be deposited on the water weed ("matsumo") or bundles of fine willow roots, where they hatch in about a week. The young are about 5 millimeters in length, and undergo the same course of feeding as the young gold-fish. The rate of growth depends very much upon the extent of the crowding in the ponds. It is found that for individuals 14 to 16 centimeters long the best rate of distribution is about two for every "tsubo" (6 feet square). Skilful culturists can push the fish, if necessary, to the length of 30 centimeters in the first year, and to 50 centimeters in two years. They are put on the market any time after the second year.

Carp culture is carried out extensively in parts of Japan other than Tokyo, especially in mountainous parts where sea fishes can be transported only with difficulty, and the industry is spreading more and more every year into all parts. One interesting reason for this is found in the circumstance that wet paddy fields in which rice is grown, and which occupy such a large portion of the cultivated area in Japan, are found in many low-lying districts to be excellent for the raising of the carp. The rice plant not only does not receive any serious injury from it, but is benefited because many insects are devoured by the carp. In the prefectures of Nagano (province Shinano) and of Gifu (province Mino) carp culture has progressed very far in this way. In Nagano, which is also noted for silk-worm raising, abundant food for the carp is found in the pupæ of the silkworm, taken out of the cocoons when these are reeled. This gives a bad flavor to the meat of the carp, however, which has therefore to undergo the process of purifying culture before it suits the taste of the fastidious. In one village in Shinano (Sakurai Mura) the agricultural society which represents the whole village undertakes to utilize 250 acres of paddy fields in the village in this way and annually raises 25,000,000 young fish to be sold and raised in the eastern provinces. In Mino, in the prefecture of Gifu, these communistic enterprises have gone further. There land is partitioned off into what are called "embankment areas"—that is, areas inclosed within a circle of embankments against the overflowing of large rivers. In one of these areas, called the Takasu embankment area, all the villages within it, with a total of 75,000 acres of paddy fields, have combined in the business of carp culture, and although the enterprise is still in its infancy, succeeded in realizing 48,000 yen in 1902. The example is being followed in other areas.

### THE EEL.

*Anguilla japonica* Temminck and Schlegel.

As has already been mentioned, in the piscicultural establishments in Fukagawa, Tokyo, and in the neighborhood of Maisaka, province Totomi, the snapping turtle, the carp, the eel, and the gray mullet ("ina"), especially the last three, are often cultivated together in the same ponds. That the eel finds itself one of this trio is due largely to the efforts of Mr. Hattori, the expert pisciculturist. He experimented long as to the best way to make eel culture a paying business, and succeeded so well that this is now the most profitable of the three fishes named.

The process is as follows: In April little eels that are brought to the Tokyo market from all the districts around the capital (Tokyo, Ibaraki, Chiba, Kanagawa, etc.) are bought. They are probably in the second year of their growth and are about 15 to 25 centimeters in length and weigh 3 to 20 grams. They are put in the same ponds with the carp and the gray mullet in varying ratios, although the total weight of the fishes put in should not exceed 610 grams per 1 tsubo (6 feet square). They are fed abundantly with the same kinds of food as the carp—that is, crushed molluscs, earthworms, etc. It is a wonderful sight when they are fed. They come crowding from all parts of the pond to the spot where food is given them, and literally thousands are seen

1. VIEW IN CARP-CULTURE ESTABLISHMENT AT SUSAKI.

2. CHITOSE SALMON HATCHERY

crowded in hopeless tangles. They climb in their eagerness some distance up almost vertical wooden walls, and, looking at them, one begins to understand how eels are able to make their way into ponds and lakes which appear inaccessible to any fish coming up from the sea.

By July they weigh on an average 40 grams and are ready to be sent to the market. When they were put in, in April, they were worth 0.80 yen per kwamme (3.75 kilograms). Three months' culture has raised their value to 1.50 to 2 yen per kwamme, giving thus a large margin of profit. They are all sold by April of the next year, when the largest reach the weight of about 110 grams. The ponds are then ready to receive the next lot.

Eel culture, as I have said, has been mainly developed by the efforts of Mr. Hattori, and all the piscicultural establishments which are more or less directly connected with him are engaged in the business. These are in Fukagawa, Tokyo, and in Maisaka, province Totomi, where the industry is being very widely taken up. I believe that there are also some who have engaged in the business before or without any relation to Mr. Hattori, but I am sorry I can not gather any facts about these at present.

### THE GRAY MULLET, "INA."

*Mugil oeur* Forskål.

This is one of the commonest fishes in the estuaries, river mouths, etc., of Japan. It penetrates in large numbers brackish ponds or any other brackish body of water, where it may grow to a large size and may be gathered in by the proprietor without his having spent any labor on it. Mr. Hattori tells me that from the culturist's point of view fear is not that there may be too few, but that there may be too many, of this fish that will get into culture ponds. The young are caught in April with a net in the sea or river near the establishments. At that time they are no more than 4 to 5 centimeters long. They are divided into two lots, according as they are to be sold that year or the next. Those that are to be sold that year are given plenty of space, not more than one or two per tsubo being put in ponds, and are fed abundantly. By September they attain the length of about 25 centimeters and weigh 225 to 860 grams, and are sold for 0.50 to 0.80 yen per kwamme. They are all sold by the end of the year.

Those that are to be sold the next year are not allowed to grow larger than 20 to 25 centimeters before April. This is accomplished by giving them not too much food and by keeping them in ponds or streams where there is a good circulation and current of water. It is found that those with plenty of fat will not live through the winter. They are all sold off by the end of the second year, for beyond this they do not keep well. They reach the length of 33 to 40 centimeters and 450 to 750 grams in weight, and fetch 0.70 to 1.10 yen per kwamme.

I should say that practically there is no limit to the demand in the Tokyo market for this fish or the eel. They can be sold in any quantity. The same is true more or less in other parts of Japan.

### THE SALMON AND TROUT, "SAKE," "MASU," "BENIMASU."

*Oncorhynchus keta* (Walbaum); *O. kisutch* (Walbaum); *O. nerka* (Walbaum).

The salmon that is most widely distributed and most abundant in Japan is the "sake" or dog salmon (*Oncorhynchus keta*). It ascends all the rivers of Hokkaido and the northern half of Honshu down to near the Bay of Tokyo, and is one of the most important wealth-producing fishes in Hokkaido. In olden times, when the annual catch was not as great as at the present day, there does not seem to have been any necessity for artificial culture. Still there were some attempts at the propagation of the fish. For instance, on the Sammen River, in the province of Echigo, salmon fishing was prohibited in a branch of the river and the salmon which entered it were caught only after they deposited eggs and by the daimio to whom the district belonged, thus securing an income for him and some safety for the salmon eggs. It was a very imperfect method, but still an attempt at propagation, and is even at the present day practiced at the same place.

The modern method of salmon culture is taken bodily from the American method, so I can communicate nothing that is new in America. As early as 1876 a Mr. Sekizawa, then an officer of the home department, inspected and carefully examined salmon and trout culture in America, and on his return started experimenting on them, which was largely imitated in the hope that these delicious fishes might be easily increased and propagated. But these undertakings were mostly on too small a scale and no important results came of them, except that Chuzenji Lake at Nikko was stocked with some American trout about this time and has since become tolerably full of fish.

Meanwhile the salmon fishery in Hokkaido was going on upon a destructive scale, and matters came to such a pass in the eighties of the last century that a need of artificial propagation was strongly felt, and an expert of the Hokkaido government, Mr. K. Ito, was sent over to America to examine into the system of salmon culture there carried on. On his return Mr. Ito established, in 1888, a hatchery at Chitose, on one of the upper branches of the Ishikari River. It was modeled after the hatchery at Craig Brook, Me. By the efforts of Mr. Ito and his successors and by the able superintendence of Mr. Fujimura, the hatchery, which has been enlarged several times, has now become the center of salmon culture (pl. VII, fig. 2). It comprises an area of over 30 acres and hatches annually 8,000,000 to 14,000,000 "sake" eggs, besides a much smaller number of trout ("masu") eggs. All the hatched fry are liberated in the Ishikari River system.

Besides the central hatchery at Chitose there are seventeen smaller hatcheries scattered all over Hokkaido, maintained by private fisheries associations with some government aid. All of these hatch between 1,000,000 and 5,000,000 eggs, while the largest of them, at Nishibetsu, may go up as high as 8,000,000. We may therefore assume that something like 35,000,000 to 50,000,000 eggs—being 37,000,000 in 1903—are annually liberated in Hokkaido.

Besides those in Hokkaido there are some five hatcheries on the main island—Honshu—supported by the five northern prefectures (Niigata, Akita, Miyagi, Awomori, and Ibareki). All of these establishments, however, are small, the largest (Niigata) hatching only a little over 2,000,000 eggs.

At Chitose and Nishibetsu, in Hokkaido, a small number of the "masu" (*O. kisutch*) are hatched, and on Lake Shikotsu, near the Chitose hatchery, there is a small branch hatchery. Here the eggs of the landlocked "beni-masu" (the Ainu "kabacheppo"—landlocked *O. nerka?*) are hatched. This fish was originally found in Lake Akanka, in the eastern part of Hokkaido; from there transplanted to Lake Shikotsu, mentioned above; from there again to Lake Onuma near Hakodate, and still farther to Lake Towada, in the Akita prefecture on the main island.

There is one interesting fact which is perhaps worth mentioning. Of the salmon fry that were liberated in the spring of 1896, 30,000 were marked by cutting off the operculum. Of these some are said to have come back in the winter of 1901–2, and two grown to the size of 2.3 and 2.4 feet are specially mentioned. In the winter of 1902–3 some twenty (according to Mr. Fujimura) were heard from, and five specially recorded. In the winter of 1903–4 some forty (according to the same authority) were heard from, and several were no doubt specially examined, but the records are not just now available. Thus the salmon liberated in one single year are returning during several years in succession, the earliest recorded being five years and a half after being set free. In the years 1897–1901 a certain number of the young fry were marked by cutting the adipose fin, and these are already being reported. All the certain recorded cases have come back to the same Ishikari River system.

I need hardly say that salmon and trout culture is still in its infancy in Japan. The dog salmon is considered by the Americans as not delicate in flavor, and we should not confine ourselves to its cultivation, but should make efforts to introduce the finer salmon and trout of America. At the same time we should undertake the culture of other members of the Salmonidæ native in Japan, such as the "shirauwo" (*Salanx microdon*), the "ayu" (*Plecoglossus altivelis*), etc.

### PISCICULTURE IN FORMOSA.

In Formosa, recently acquired by Japan, the native Chinese engage in the culture of various species of fishes, such as the carp, the gray mullet, the crucian carp, etc. Of these, two stand out prominent. One species belonging to the Clupeidæ and called in Chinese "sabahi" (*Chanos salmoneus* Bloch and Schneider) is abundantly cultivated in the southern parts. Although a sea fish, it is able to accommodate itself easily to fresh water. The fish are at first put, when small fry, into ponds not more than 4 feet square, and are fed with hen's eggs. When grown to a larger size, in twenty to thirty days, they are put in larger ponds, given plenty of food, and when they reach the size of 10 inches or more are put on the market. The other fish much cultivated is called "lenhi" (*Hypophthalmichthys molitrix* Cuvier and Valenciennes), belonging to the Cyprinidæ. These are brought from China in November and December, when 9 to 10 inches long. They are kept in ponds and abundantly fed, and may reach the size of 3½ feet, but are sold from the time they become 1 foot long. This fish is cultivated in all parts of Formosa.

### THE OYSTER.

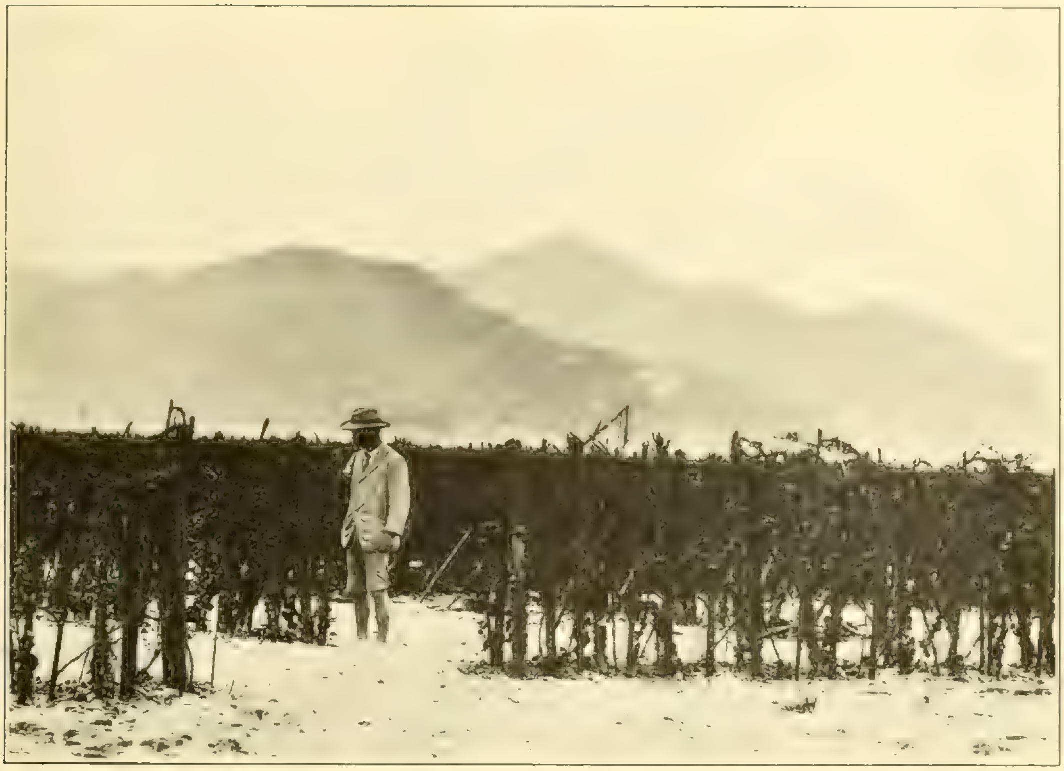
*Ostrea cucullata* Born.

The oyster has probably been longer under cultivation by man than has any other mollusk, and it is also the most extensively cultivated. As to the former point, I need only refer to Roman pictures delineating oyster rearing, and as to the latter to the extensive enterprises carried on at the present day in Europe and America. In Japan also the luscious mollusk received an early attention, and its culture is becoming more and more extensive. The first place where this was done systematically appears to have been the neighborhood of Hiroshima, a town about in the middle of the length of the Inland Sea and on the north side of that waterway. There is a record preserved there showing that the art of oyster raising was well understood certainly one hundred and eighty years ago, and the practice is no doubt much older. There were several reasons why it should prosper here, among which may be mentioned (1) that the sea about there is as quiet as a lake; (2) that the differences of level between the high and low water marks are comparatively great, being 10 to 15 feet, thus exposing a very wide area adapted for oyster cultivation; (3) the bottom of the sea is rather firm there, being composed of finely ground granite; (4) lots were early divided and leased to individuals, thus securing the utmost exertions of those lessees; (5) monopoly was acquired by the people of this region in selling oysters in Osaka, thus ensuring a large market.

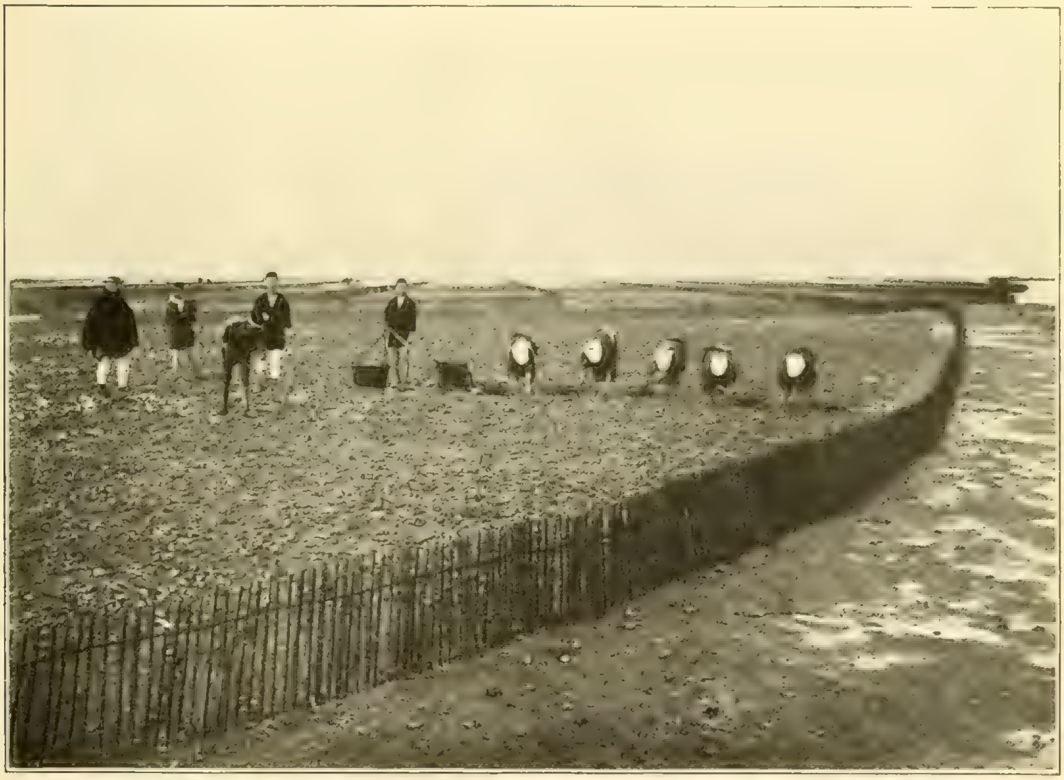
I made in 1894 a careful inspection of the oyster industry of Hiroshima at the request of the department of agriculture of the Japanese Government and wrote a report on it (in Japanese). This has been, in its main outline, together with some valuable additions of his own, put in English by Prof. Bashford Dean, of New York (U. S. Fish Commission Bulletin for 1902, pp. 17–37, pls. 3–7), and the reader may be referred to it for details. I shall, however, touch here, though briefly, on various systems carried out around Hiroshima, for they are, after all, the most complete of any known in Japan.

The simplest method among them is practiced in a village called Kaidaichi, a few miles east of the city of Hiroshima. When the tide is in this bay is a quiet, placid piece of water; one sees nothing unusual unless he looks deep below the surface and notices long lines of bamboo fences. When the tide is out the scene takes on an entirely different aspect. One sees that the entire area, only so recently covered by the water and over which one glided in a boat, seems to be cut up into lots looking very much like town lots, with streets intersecting. Two examples of these lots are given in cuts 5 and 6. The lines in the figures indicate bamboo collectors on which the oyster spat becomes attached and grows, the full lines representing those that were put up any one year, and the dotted lines those of the year previous. Figure 1, plate VIII, shows how these bamboo collectors and oyster fields look. From a distance the sight reminded me of nothing so much as vine trellises in the Rhine vineyards. The spat that is collected on these bamboo fences is left to grow on them until the winter of the next year—that is, only a little more than a year from the beginning. Then the bamboo collectors are taken down, the oysters are beaten off and are then ready to be sent to the market.

The oysters are necessarily small, for unfortunately there is no place in this bay to allow their further growth, as the bottom is too soft and they would become



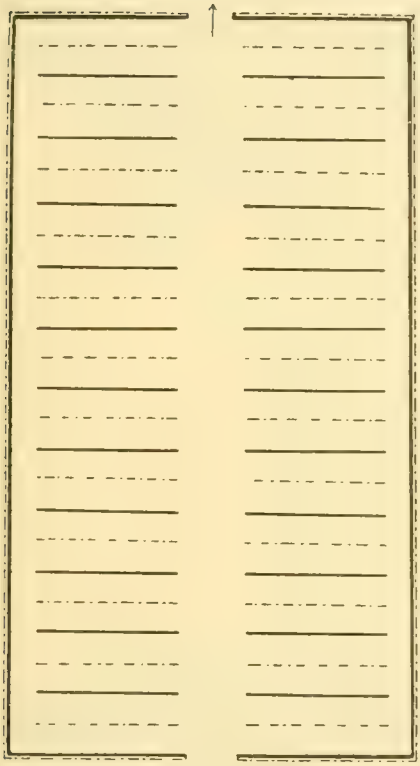
1. OYSTER FARM IN KAIDAICHI



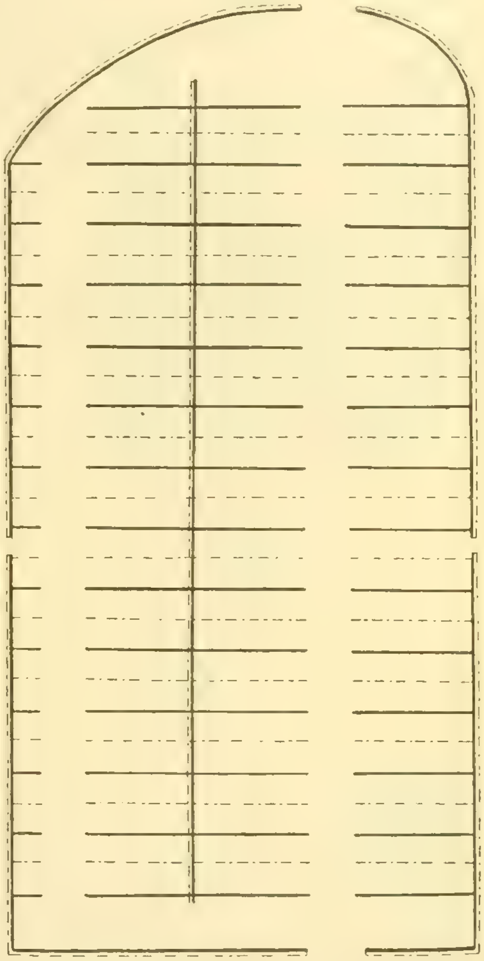
2. OYSTER GROUNDS AT KUSATSU, SHOWING LIVING GROUND (FOREGROUND) AND MATURING GROUND INCLOSURE IN THE DISTANCE

buried in mud. This, then, is a very simple system—to collect the oyster spat on bamboo fences, to let it grow on them until a little over a year old, and then to send the oysters to the market.

The method known as the Kusatsu system is practiced in the village after which it is named as well as in all other villages that lie to the west of Hiroshima. Four or five bamboo sticks about 4 feet long are made into clusters and stuck firmly into the bottom so that about 3 feet is left above ground (cut 7). These clumps are arranged in long rows, generally over 1,000 feet in length, each row being in reality double, with clumps in each of these two subordinate rows set alternately. On these clumps the oyster spat is collected, and the young oysters are allowed to grow on them until April of the next year. At that time the old collectors have to give place to the new set of collectors to be ready for the spat that will soon be shed. Young oysters



CUT 5.—Typical oyster farm, Kaida Bay.

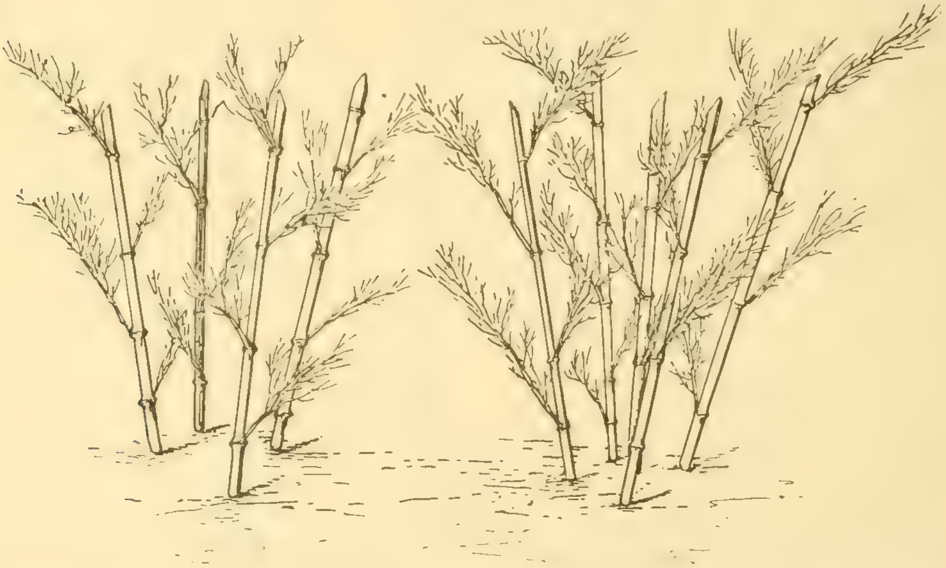


CUT 6.—Diagram of well-developed oyster farm.

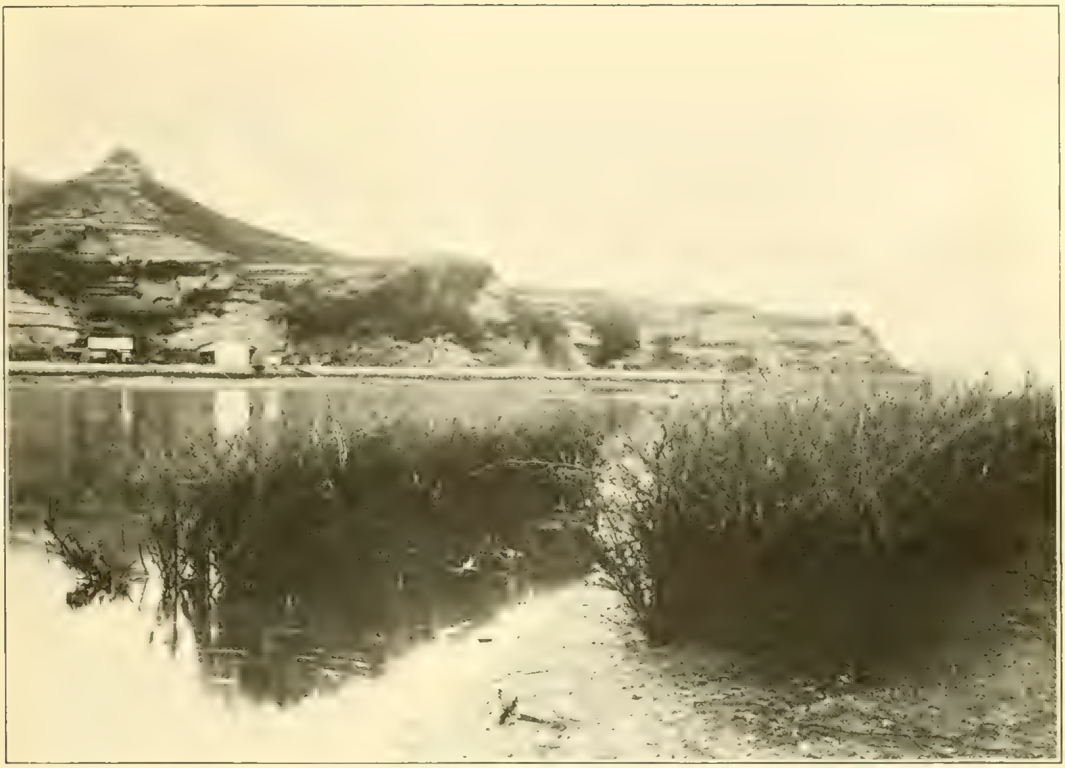
The black lines in figs. 5 and 6 represent newly arranged bamboo collectors, the dotted lines the collectors of the second year.

are therefore struck off the collectors at that time and taken to the place called "ike-ba" (literally living-ground), where they are placed directly on the rather firm. gravelly sea bottom, and allowed to grow there until the cold season of the third year. These "ike-ba" may be some distance from, or quite near, the spat-collecting ground, according to the circumstances of each collector and how and where he can get a good bottom for the purpose. Finally, toward the cold season of the third year the oysters are removed to the "miire-ba," or maturing-ground, which is to receive all that are ready for the market. This ground must, of course, be quite near the culturist, and easily accessible. Figure 2, plate VIII, shows oyster grounds at Kusatsu, and conveys a good idea of their extent.

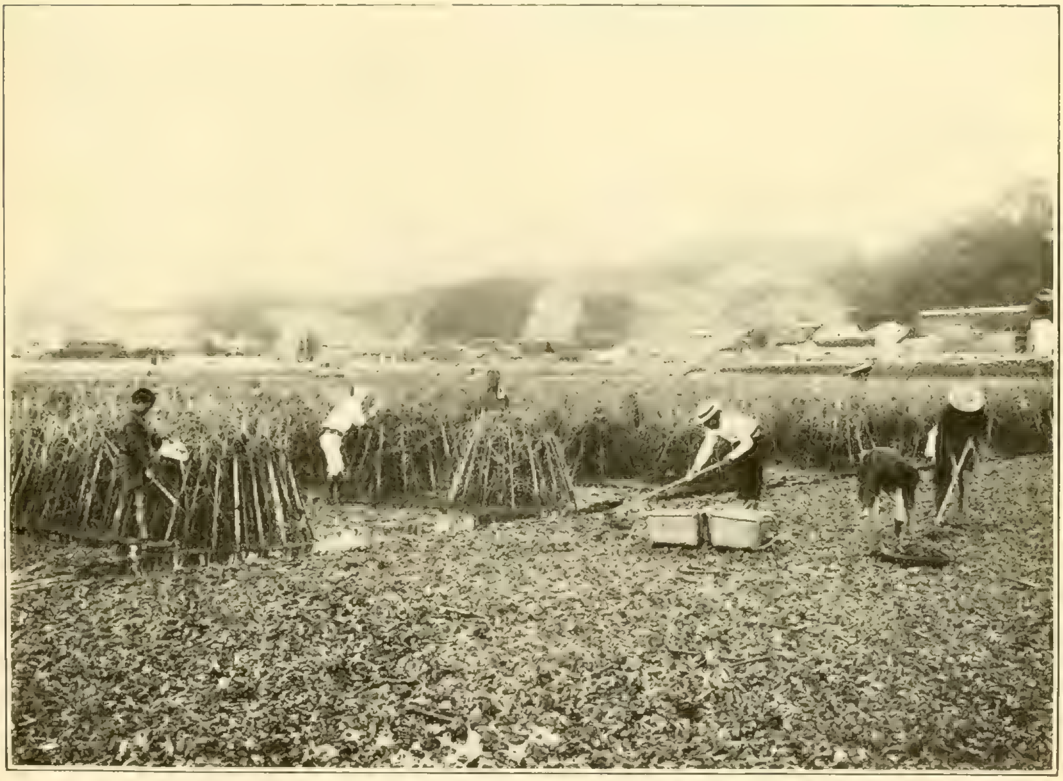
At Nihojima, about 2 miles east of Hiroshima, the nature of the oyster grounds has necessitated the development of a most elaborate system of oyster culture. Here the main part of the grounds is in a sheltered inlet, or rather in an enlarged mouth of a river, which naturally brings down a great deal of fresh water. As I think, for this very reason the spat collecting is done just outside the inlet. Here, in April, when the breeding season begins, bamboo collectors, four or five in a bundle, are planted in close clusters along the channel to receive the spat. Figure 1, plate IX, shows two of these clusters. At the end of the breeding season—that is, in the latter part of August—the collectors are uprooted and conveyed inside the inlet, care being taken not to injure the spat upon them. There they are built into peculiar structures called "toya," which are round pyramidal in shape, and measure about 3 to 4 feet high and 5 to 6 feet across at the bottom (see fig. 2, pl. IX, left side). A "toya" is constructed (cut 8) as follows: In the center are small bamboo collectors of last year on which some young oysters are still adherent. Outside of these the new bamboo collectors which have just been brought in from the spat-collecting ground with tiny oysters adherent on them are placed in two circles, one outside



CUT 7.—Bamboo collectors arranged after the fashion common in Kusatsu. They stand about 3 feet above the bottom and their tips diverge; the clumps are set 4 or 5 feet apart.



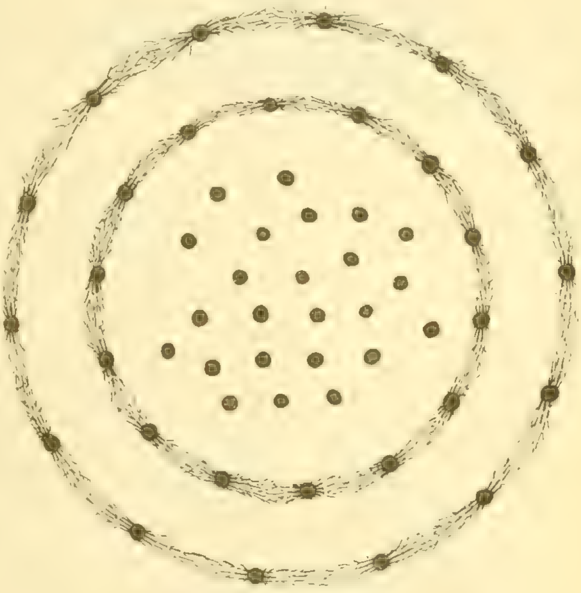
1. SPAT COLLECTORS OUTSIDE NIHOJIMA INLET.



2. NIHOJIMA OYSTER GROUNDS, SHOWING "TOYA" GROUND AND LIVING GROUND.

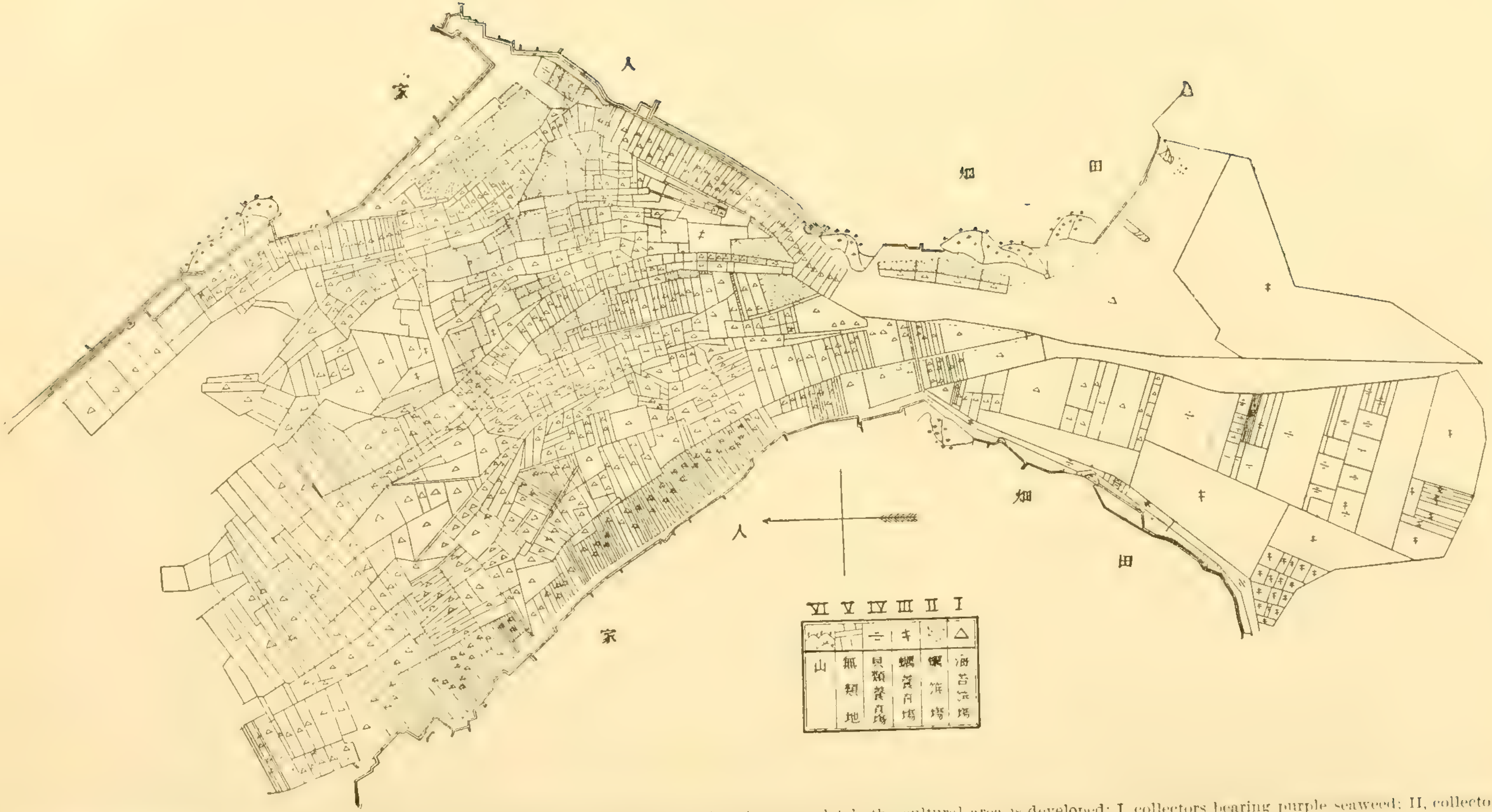
the other, the bamboo branches being made to interlock. The "toyas" are left in this condition exactly one year, when they must give place to the next new set.

The oysters that are now in their second year and are of a fair size are struck off the bamboo collectors, which are rotten by this time, and are then placed in the living ground (fig. 2, pl. IX, right side), where they lie directly on the hard and gravelly bottom. They are left here until the next year, although they are given thorough raking every fortnight or so. By autumn of the third year they are ready for the market. How completely the sea bottom in the inlet of Nihojima has been utilized may be gathered from the accompanying photograph and map. The photograph (fig. 1, pl. X) was taken at low tide, when the oyster living grounds and "toya" grounds are fully exposed. The map (cut 9) gives an idea as to how this sea bottom has been cut up into lots and leased to different persons. Put this together with the fact which you can gather from some of these photographs (fig. 1, pl. IX and fig. 1, pl. X), that hills around here are cultivated to the very top—it would be difficult to go beyond this in the utilization of land and water. Hiroshima has perhaps gone ahead of most places in Japan in this respect.

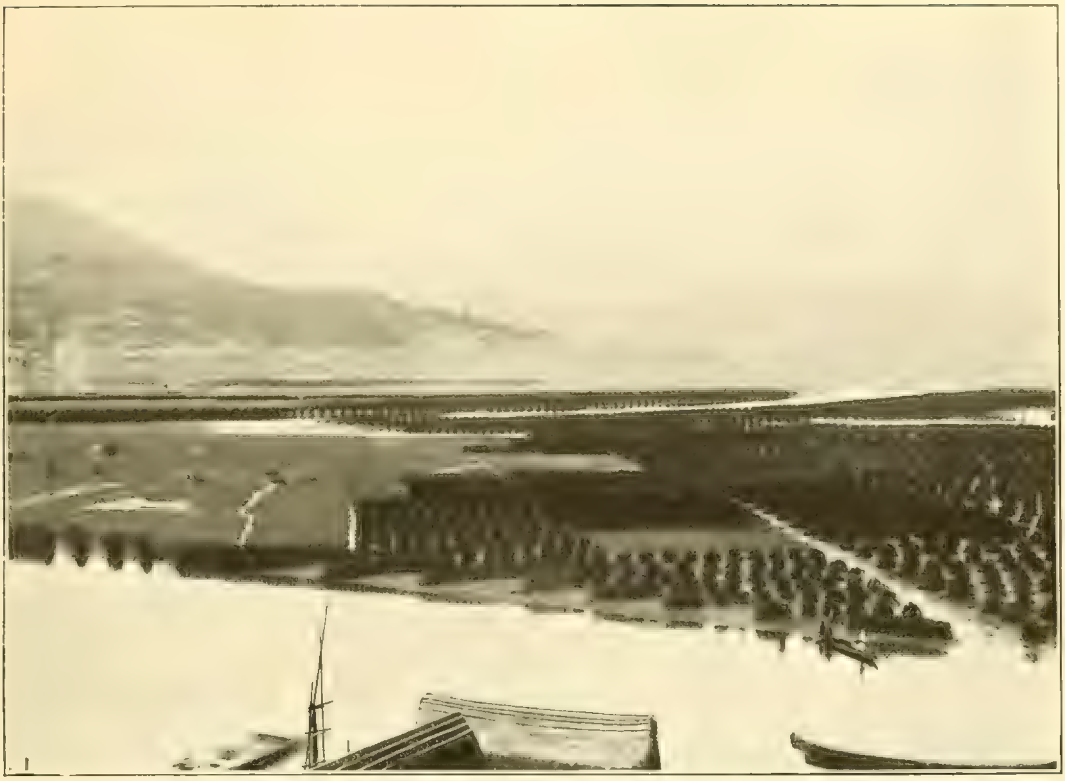


CUT 8.—Ground plan of a "toya." Collectors bearing well-grown oysters are indicated by the black spots within the two circles of branching collectors.

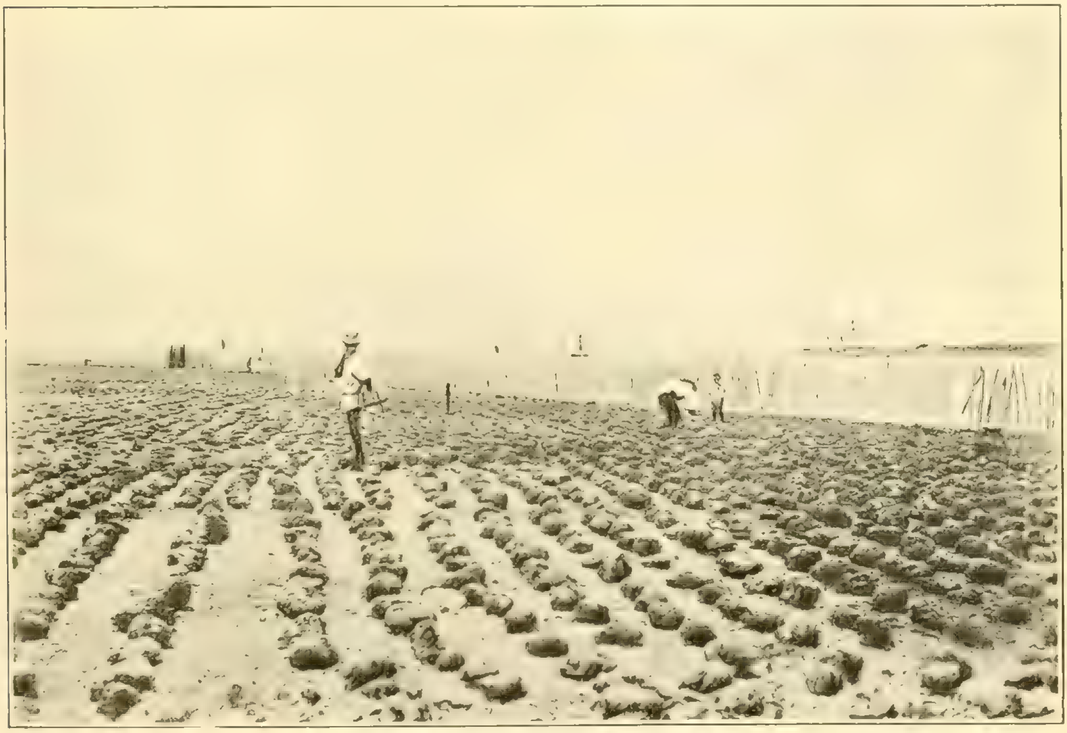
A rather interesting and simple system of oyster culture has been developed within the last twenty years at the mouth of the Suminouye River, in Ariake Bay, in the prefecture of Saga, Kiushiu. It seems that people here were in the habit of collecting all the natural oysters they could and of preserving larger ones among them for a little while on the bottom of the Suminouye River to be sent later to Nagasaki for sale. For some reason, in 1884 those thus preserved were left over winter and it was discovered that by next year they had grown to a large size. This fact was not lost on the sagacious people thereabouts, of whom Mr. Murata, an enthusiastic culturist, seems to have been the head and soul. From this beginning the industry was developed so that 18,330 bushels of oysters, valued at 21,181 yen, were produced in 1897, and the output has no doubt increased since. The method is as follows: Young oysters about an inch or more in length are collected constantly from July till March of the next year from stone walls, old shells, etc. All these are placed on oyster beds in the river mouth, and as these small ones may be choked by being covered up with the silt, they are heaped close together in masses, and are moreover washed and cleaned two or three times in a month, at low tide. In April these oysters are stuck into the mud almost vertically with the hinge-end below


家
人
畑
田
人
畑
田
家
I
II
III
IV
V
VI
△
海苔篊場
蠣篊場
蠣養育場
貝類養育場
無類地
山

Cut 9.—Map of the oyster and seaweed concessions in one of the estuaries of Nihojima, to show how completely the cultural area is developed: I, collectors bearing purple seaweed; II, collectors bearing oysters; III, grounds for rearing oysters; IV, cultural area for other mollusks, Tapes, Arca, etc.



1. GENERAL VIEW OF NIHOJIMA INLET WHEN THE TIDE IS OUT, SHOWING "TOYA" GROUNDS AND LIVING GROUNDS.



2. OYSTER GROUNDS NEAR TAMSUI, FORMOSA.

and with the ventral margin above. As the mud is firm, they seem not only to keep this position, but also to grow finely. They are often cleaned, and as they grow they are often thinned out and given more space. In August and September they grow most rapidly. By October they are 6 by 5 inches in size and ready for the market. I think the rapid growth, the round shape, and the large size must distinguish this from the ordinary Japanese species of oyster. This system seems very profitable, as 1 tsubo (6 feet square) is said to give a return of 3 yen. In Formosa there is also a system of oyster culture practiced by the Chinese. Figure 2, plate x, gives a view of an oyster farm near Tamsui, on that island. Large blocks of stone are arranged 1 foot apart in regular rows, and on these the spat is collected and the oysters are left to grow.

There are various other methods and variations of methods carried on with more or less success in different parts of Japan, and they are increasing every year.

## THE PEARL OYSTER.

*Avicula martensii* Dunker.

Various kinds of pearl oysters are found in the southern semitropical islands of Japan, but the only one which is at all common in Japan proper is the species named above. This pearl oyster is found more or less along the whole of the coast of Japan, but there are some localities famous for producing it in quantities. Such are Shima, Omura (province Hizen in Kiushiu), Noto, Tosa, etc., and some fine pearls have been obtained from these places. As in so many other matters in Japan, there was a time after the restoration of 1868 when the fishery for these precious shells was thrown into a chaotic state, and, as is usual in such a case, carried to an excess, so that the yield of pearls dwindled to almost nothing.

In 1890 I suggested to a Mr. Mikimoto, a native of Shima, who had grown up and lived in the midst of the pearl-producing district, the desirability of cultivating the pearl oyster. He took up the subject eagerly and began making experiments on it. Soon after I pointed out to him also the possibility of making the pearl oyster produce pearls by giving artificial stimuli. He at once proceeded to experiment on it. The results have been beyond expectations, and to-day the Mikimoto pearl-oyster farm, put on a commercial basis, has millions of pearl oysters living on its culture grounds, and is able to place annually a large crop of pearls on the market.

The Mikimoto pearl oyster farm is in the Bay of Ago, on the Pacific side of central Japan, a few miles south of the famous Temple of Ise. The bay, like all in which the pearl oyster grows in abundance, is a very quiet piece of water with a most irregular, highly broken-up coast line full of deep-running inlets, coves, etc., with a depth of 3 to 7 fathoms, and affording most favorable shelter. Somewhat out of the center of the bay to the north there is a little island called Tadoko, where the land part of the enterprise, necessary buildings, etc., are placed, and where altogether about 100 persons connected in some way with pearl-oyster culture are now living. Around and in the neighborhood of this island a large area of sea bottom, which with several large recent additions now amounts to 1,000 acres, has been leased by Mr. Mikimoto.

The farm is divided into two portions: (1) Those parts where the spat is collected and the young are kept to their third year, and (2) the parts where the shells older than 3 years are kept. The breeding season of the pearl oyster is July to August, and before this comes round—namely, in May to June—stones 6 to 8 pounds in weight are placed over the bottom of the spat-collecting grounds, which are generally in shallower parts, penetrating deep into land. By August tiny shells not more than 3 to 4 millimeters long are first discovered, attached to these stones by their byssus, and the number increases steadily with the season. An immense number of shells is collected every year. They are allowed to lie as they are until November, and then those that are too near the shore are removed with the stones on which they are anchored into depths greater than 5 or 6 feet. This is necessary to protect them from cold, from the effects of which they are apt to die in the course of winter if left in the original places. The young shells are then left quietly and allowed to grow for three years, or, better, some may be removed to deeper waters and where they are given more space and get more food, and grow better. At the end of three years, when they are about 5 to 6 cm. across, they are taken out of the water and the operations necessary for inducing them to produce pearls—that is, of putting in nuclei for pearls—are performed on them. At present the number thus operated on in a year is only 250,000 to 300,000. They are then put back in the sea and spread out at the rate of about 30 to every tsubo (6 feet square), and are left alone for four years more. At the end of that time, or seven years and a half from the beginning, they are taken out of the water and opened. Natural pearls, as well as "culture pearls," as I have named those produced from the introduced nuclei, are thus harvested and put on the market.

As in all culture enterprises, there are many enemies of the pearl oyster, as well as unexpected difficulties in the way of its culture. *Octopus*, *Codium*, *Clione* (sponges), all sometimes play a sad havoc among the mollusks, but the most dreaded enemy of all is the "red current" or "red tide." This is an immense accumulation of a Dinoflagellata, *Gonyaulax*, causing discoloration of the sea water, and, in some way not well accounted for, causing in its wake an immense destruction of marine organisms, large and small.

The "culture pearls" (fig. 1, pl. XI) are, I regret to say, either half pearls or only a little more than half pearls, but as regards luster, shape, and size, they are beautiful beyond expectations, and meet the requirements completely in cases where only half pearls are needed.

Pearl-oyster culture is still in its infancy, but its promises are bright. If, in addition to half pearls, full or "free" pearls can be produced at will, as there are some hopes, it will be a great triumph for applied zoology.

### THE ARK-SHELL, "HAIGAI."

### *Arca granosa* Lischke.

One of the most interesting cultural enterprises in Japan is that with the ark-shell (*Arca granosa*), or "haigai" as we call it. This was originally and is at the present day most extensively carried on at Kojima Bay, near Okayama. This bay opens into the Inland Sea by a narrow mouth, hardly a mile across, and is about 8 miles in length by 6 miles of breadth. The differences between high and low tide marks are comparatively great here as in all parts of the Inland Sea, being 5 to 7 feet, and at low tide the whole of the bottom of the bay is exposed, leaving only four river channels which run through the bay to its mouth. This flat is the area utilized for the cultivation of *Arca granosa*. It seems that this idea was present in the minds of some of the people as far back as the sixties in the last century, and was actually put in practice by 1869. At the beginning different individuals undertook the cultivation by themselves, and the conflict of interests soon became the source of endless disputes. People soon getting tired of this, it was agreed in 1886 to form an association in which all the conflicting interests were amalgamated, and as this worked very smoothly, it was organized in 1890 into a stock company. At present a little over 830 acres of the bottom is utilized, the cultivated areas being scattered mostly along the southern and western sides of the bay. The annual sale amounts to 75,000 to 100,000 bushels, valued at more than 30,000 yen, and yielding a return of 40 to 60 per cent on the capital invested.

The method of culture is as follows: By September or October of every year, the larvæ of the mollusk, quitting their swimming stage, have become tiny shells not more than 2 or 3 millimeters long, buried directly below the surface of the bottom mud. These are collected from various parts of the bay by an ingenious instrument which may be described as a huge comb more than 6 feet long, being a series of short pieces of wire with their points slightly bent, and planted with the other end on a piece of board. This, being applied on another piece of plank, is forcibly pushed along the mud bottom with the tooth part down, and all the tiny shells in the mud are caught between the teeth of the comb and accumulated on the bent ends of the wire. These are collected once in a while and put into a tub, after which another raking is gone through. The distance between the wires regulates the size of the shells to be caught. If the interval is large the shells caught are naturally large, and vice versa.

These tiny shells collected from various parts of the bay are placed in the culture grounds. It has been found that the best size for starting culture is quite small—that is, one which will go in to the number of 30,000 to 70,000 per "sho" (1.58 quarts or 1.8 liters). In order to distribute them over the ground allotted to them, the little shells which have been collected are heaped up in a boat. One man rows the boat along slowly and two others measure out the shells and throw them overboard with wooden scoops. The quantity of shells that can be most profitably put into a unit area differs of course with the size and age of the shells, and has been very carefully studied out.

The tiny shells that in September are only 2 to 3 millimeters across and run 30,000 to 70,000 to a "sho," grow by the autumn of the next—that is, the second—year to nearly 20 millimeters in length and run only 1,000 to a "sho." In the autumn of the third year their average length is already 32 millimeters and they run only 200 to a "sho," and by the autumn of the fourth year they become 42 millimeters long or only 120 to a "sho."

As the shells grow their number per unit area must be diminished to the proper number determined by previous experience, and all the superfluous ones must be removed to near lots. These culture grounds show therefore a large number of partitioned or marked areas, each of which contains a special lot as regards size and age, and give one an idea of the most methodical procedure.

It has been found that the crop of tiny shells which can be collected each season differs greatly in amount with different years. For instance, in 1893 the crop was very large, amounting to 14,145 bushels, but in the following year there were only 15 bushels, and in the two years after that matters were still worse, there being practically none at all. In order, therefore, to have the market supply constant and not fluctuating as these "seed" shells, it has been found possible to retard the growth of the shells. That is, after they reach a size of 2,000 to a "sho" they are removed to a somewhat deeper place, where the current is slow and where they are no doubt also kept more crowded than usual. This has been found enough to make their growth slower, and the seed shells collected in one year can thus be depended on to supply the market for five years.

The 3-year old shells are exported in the fresh condition to China, where they are very much valued, while the 4-year old and the older are consumed in Japan.

Another species of *Arca* (*A. subcrenata* Lischke) is cultivated more or less in the same Kojima Bay, but this shell flourishes best in deeper waters which are not exposed at low tide and where seaweeds are growing. Such a condition is found in Nakano-Umi near Matsui, province Isumo, on the Japan Sea side, where the ark-shell has now been cultivated for over a hundred years. The system of culture is that of rotary crops, giving fine results. The area under cultivation is at the present day about 2,631 acres.

### THE RAZOR CLAM, "AGEMAKI."

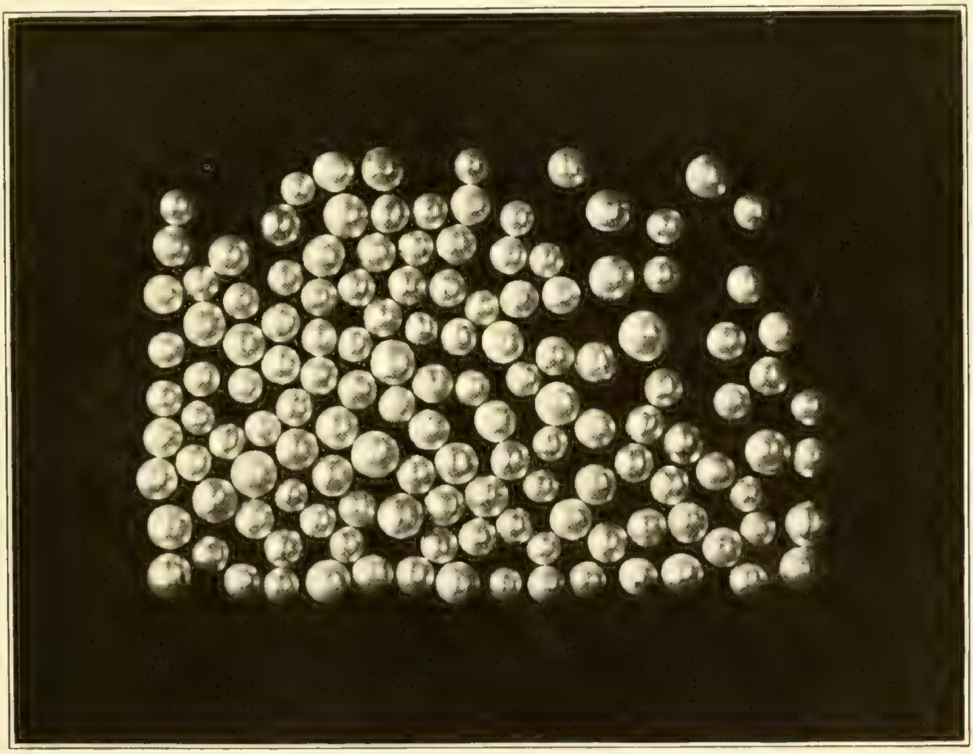
*Solecurtus constricta* Lamarck.

Reference has been made to a peculiar system of oyster culture begun lately in the mouth of the Suminouye River in Ariake Bay. The shores of the same bay have extensive mud flats exposed more or less at low tide and here the cultivation of two other animals has gradually been developed, "agemaki" (*Solecurtus constricta*), a shell somewhat resembling razor shells, and barnacles (*Balanus* sp.).

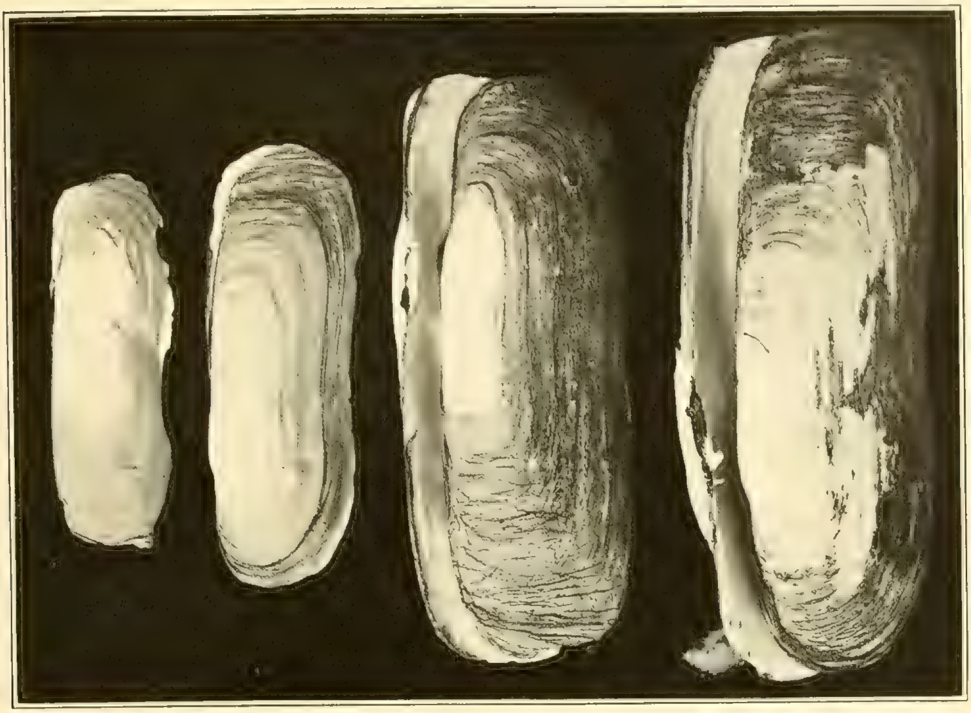
The first of these ("agemaki," fig. 2, pl. XI) is dried and exported to China. The trade began in 1875, and increased so rapidly that by 1882–83 the supply was not equal to the demand, and owing to the consequent overfishing the shells caught were becoming smaller and smaller. To remedy this state of things, the Department of Agriculture and Commerce established there an experiment station for the cultivation of the shell, and one Mr. Negishi, belonging to the district, one year put in, for trial, about 135 bushels of the shell in the tide flats, and found that these had increased by the following year to 820 bushels, thus thoroughly demonstrating the practicability of the culture. From this beginning the industry increased so rapidly that by 1896 in this part of the bay alone over 700 acres[a] were under cultivation and about 50,000 bushels of seed shells were collected, and 112,845 bushels sold, fetching 79,329 yen. The cultivation has since extended to other parts of Ariake Bay, and promises to become more and more important.

---

[a] The calculation of areas on the sea bottom in Japan is very rough and only approximate. As a general thing it falls far short of the actualities.



1. CULTURE PEARLS, NATURAL SIZE.



2. "AGEMAKI" SHELLS.

The method of culture is very simple. The young are collected all over Ariake Bay in July and August of each year. They are then between 4 and 5 centimeters in length, and are dug out by spades and hands and then transplanted to culture grounds, care being taken to protect them from the sun's rays during the passage. Arrived at the culture grounds they are scattered about and soon find their way into the mud of the bottom, which must therefore be well adapted for the life of this mollusk.

These shells are left for about three years. According to the specimens given me by Mr. Fujita for examination, at the end of the first year after transplanting they are 5.6 centimeters long; at the end of the second year, 6.6 centimeters; at the end of the third year, 9 centimeters; and at the end of the fourth year, 10 centimeters. In some parts growth is no doubt more rapid.

### BARNACLES, "JIMEGI."

*Balanus* sp.

Further out in the same tide flats where the agemaki is cultivated as described in the previous section, there are planted bunches of bamboo collectors that look like the collectors for oyster spat. Here, however, they are to collect a species that is generally considered injurious to cultural enterprises—namely, the barnacle. The collectors are put up twice in a year—that is, in the spring and in late August. The spring collectors begin to be taken down after sixty days and it is thirty days more before they are all disposed of. The autumn collectors are left standing one hundred days, after which they are gradually taken away before the next March. The barnacles that are attached to the collectors are beaten off and used as manure. The annual yield is 400,000 bushels, fetching 30,000 yen. This cultivation has been going on ever since 1830 or thereabouts.

### MISCELLANEOUS.

"Tairagai" (*Pinna japonica* Reeve). The cultivation of *Pinna* is confined to a small village on the Inland Sea, but it is interesting as a specimen of what can be done in the way of mollusk cultivation. A little west of Onomichi, a large town on the north side of the Inland Sea, there is a small village called Hosojima. It has only twenty-five households, but each of these twenty-five possesses a small *Pinna* culture ground of its own, not more than 50 by 30 feet.

Every October young *Pinna*, between 7 and 8 centimeters long, are collected at a shoal near the village and put rather thickly into the culture grounds. The triangular shell, upright, with the acute apex below, is buried in the mud to the edge of the shell and placed in such a way that the hinge line is toward the land and the open gaping side toward the sea, thus preventing the muddy water that runs down from entering the mantle cavity of the mollusk. By October of the next year the shells have increased about two and one-half times in size, although they are said to decrease in number 40 per cent, and will not grow much more even if left longer. They are then taken out, and new, young shells are put in their place.

Egg cases of Gastropoda. The peculiar leathery egg cases of various gastropods have a commercial value in Japan. You see them sold in the streets, dyed red, each costing about half a cent. They are bought by young girls. The cases are turned about in the mouth, and when filled with air and then squeezed between the tongue and the roof of the mouth emit a peculiar sound. The same use is made of the fruit of a plant (hozuki), and the mollusk egg cases serving the purpose are called "umi-hozuki" (sea hozuki). These toy things are in such a demand that the supply can not be left simply to the accidental finding of them, and so various methods of cultivating them have been devised in different parts of Japan. In Chiba boxes are constructed 6 by 3 feet and 2 feet high, with wooden sides and covered with bamboo basket work on the top and the bottom, and in these large whelks (*Rapana bezoar*) are placed and the whole left floating in the sea. The mollusks soon deposit their egg cases on the wooden sides. In Noto pine sticks 2 to 3 feet long are anchored by a line and a weight and are left floating in the sea for the mollusks (*Fusus inconstans*) to come and deposit their egg cases on them. In Okayama inverted bamboo baskets are kept anchored in the same way and serve as the repository of the eggs. There are, no doubt, other methods in other places. These egg cases, although mere toys, must altogether be worth several tens of thousands of yen. Chiba alone produces them to the value of 30,000 yen and Noto 10,000 yen.

"Bakagai" (*Mactra sulcatoria* Deshayes); "asari" (*Tapes philippinarum* Adam and Reeve); "shijimi" (*Corbicula atrata* Prime, and other species). These mollusks, especially the last two, are very common and are consumed in enormous quantities, which facts have naturally led to a greater or less amount of cultivation in some places. They may be collected when young and allowed to grow in culture grounds, or they may be allowed to grow by systems of rotary crops. Methods would seem to differ in different places.

The trepang, "namako" (*Stichopus japonicus* Selenka). In a recent paper of mine (Notes on the Habits and Life History of *Stichopus japonicus* Selenka, Annotations, Zoological Japonicæ, Vol. V., pt. 1), I offered suggestions on the method of propagation of this holothurian, after a study of its life history. My ideas have not yet been given a fair trial, but in Mikawa Bay, where a part of them have been enforced, the complaint of the decrease of the supply, at least, seems to have ceased. I may perhaps be allowed to quote the last paragraph of the paper. "After I had thought out these measures of protection for *Stichopus japonicus* from its habits and life history, my friend, Doctor Kishinouye, was traveling in the somewhat out-of-the-way island of Oki and found that people there had been a hundred years or more in the habit of putting up loose stone piles in the shallow sea in order to obtain a supply of the holothurians. A village headman had thought it out from practical experiences. Verily there is nothing new under the sun."

"Amanori" (*Porphyra tenera* Kjellman); "Funori" (*Gloiopeltis furcata* Post and Ruprecht). Although the present discussion is on the cultivation of animals, I can not help alluding at the end to the cultivation of some seaweeds, as one of them at least is very important indeed. The "amanori" or "asakusanori" is most extensively cultivated in various parts of Japan. Of all places, however, the system has reached greatest perfection at Shinagawa and Omori, at the mouth of the Sumida River, which passes through Tokyo. In the late autumn or in the winter you can see here miles upon miles of culture areas in which tree branches are set up as collectors. During the cold season the alga keeps growing on them, and any fair day you can see hundreds of little skiffs, mostly with women and young girls, going out to collect it. Being brought home, the plant is thoroughly cleansed and then made and dried in the shape of thin rectangular sheets about 25 by 18 cm., looking very much like sheets of dark paper. In this state it can be kept for a long time and is sold in shops. When slightly roasted the sheets have a peculiar taste and are used much to give flavor to various articles of diet. The production about Tokyo alone is over 1,000,000 yen, and for the whole country it must of course be much more.

"Funori" (*Gloiopeltis*) is used as the starch-yielding source in the manufacture of various kinds of silk and cotton goods and in washing, and is one of the most important articles produced by the sea. Its cultivation is not as extensive as that of the amanori, but, according to Mr. Endo, it is undertaken to some extent in the village of Shimofuro, in the district of Shimokita, prefecture of Aomori, on the south side of the strait between Hokkaido and Honshu. At that place there is a large ledge of rock that is exposed at low tide. Here people place 700 to 800 large blocks of stone, and the alga, which grows between tide marks, soon becomes attached to these. After five or six years, when the blocks become too old and the alga no longer grows on them, they are pushed into deeper parts and new blocks are placed in their stead.

I think I have now given—how imperfectly, I am but too well aware—a brief survey of the marine and fresh water animals cultivated in Japan. The subject has always been an attractive one to me, as it might in many respects be called applied embryology. Aside from its immediate economical results, there are many things in it which might be utilized to solve problems in heredity, growth, ecology, etc.

In conclusion, I wish to express my thanks to all who helped me in the preparation of this paper. Especially I would mention Doctor Kishinouye, Messrs. Fujita, Mikimoto, Nishikawa, Wada, Fujimura, and Hattori. To Mr. Uchiyama, my assistant, I am indebted for much painstaking photographic work.

# NEW STARFISHES FROM DEEP WATER OFF CALIFORNIA AND ALASKA.

BY

WALTER K. FISHER,
*Assistant in Zoology, Leland Stanford Junior University.*

# NEW STARFISHES FROM DEEP WATER OFF CALIFORNIA AND ALASKA.

By WALTER K. FISHER.

*Assistant in Zoology, Leland Stanford Junior University.*

In this paper are described 1 genus, 2 subgenera, and 24 species of starfishes believed to be new. They are as follows:

Eremicaster, new subgenus.
Porcellanaster (Eremicaster) tenebrarius.
Bathybiaster pectinatus.
Dipsacaster eximius.
Persephonaster penicillatus.
Benthopecten acanthanotus.
Dytaster gilberti.
Mimaster swifti.
Odontaster crassus.
Pseudarchaster alascensis.
Pseudarchaster pusillus.
Tosia leptocerama.
Mediaster tenellus.
Hippasteria heathi.
Hippasteria californica.
Cryptopeltaster, new genus.
Cryptopeltaster lepidonotus.
Lophaster furcilliger.
Peribolaster biserialis.
Pteraster jordani.
Hymenaster quadrispinosus.
Zoroaster ophiurus.
Myxoderma, new subgenus.
Zoroaster (Myxoderma) sacculatus.
Zoroaster (Myxoderma) evermanni.
Brisinga exilis.
Freyella fecunda.

One subfamily, the Pseudarchasterinæ, is raised to family rank.

The specimens on which these descriptions are based were dredged by the steamer *Albatross* in Alaskan waters during the summer of 1903, and off the coast of southern and central California in the spring of 1904. In the final reports on these dredging operations numerous figures of all the new forms will be published. The collections are the property of the U. S. Bureau of Fisheries and are temporarily deposited in the zoological museum of Stanford University for study. A full series, including the types, will eventually be deposited in the U. S. National Museum.

## Family PORCELLANASTERIDÆ Sladen, 1889.

### Genus PORCELLANASTER Wyville Thomson.

*Porcellanaster* Wyville Thomson, Voyage of *Challenger*, Atlantic, I, 378, 1877 (*P. cæruleus* Thomson).

### EREMICASTER, new subgenus.

Differs from typical *Porcellanaster* in having 3 cribriform organs to each interradius; segmental pits and papillæ present; adambulacral plates with 1 or 2 spines. Type, *Porcellanaster* (*Eremicaster*) *tenebrarius*, new species.

### Porcellanaster (Eremicaster) tenebrarius, new species.

Rays 5. R=37 mm.; r=12 mm. R=3 r. Breadth of ray at interradial line, 14 to 15 mm.; at outer edge of lateral cribriform organ, 9 mm.; height of epiproctal cone, 3 to 5 mm., in differert specimens.

Rays elongate, stout, fairly slender, abruptly tapering at base, but very gradually on outer three-fourths; interbrachial arcs wide and well rounded; disk only slightly or not at all inflated; ambulacral furrows very wide; actinostome large; rays more or less reflexed, but not greatly curved.

Abactinal area slightly sunken below level of inner edge of superomarginal plates; fairly narrow on rays (4 mm. wide at outer edge of lateral cribriform organs, 2 mm. at middle of ray); integument thin but resistant, covered with simple, slender spinelets which are well spaced, sheathed in membrane, and slightly longer toward edge of disk than in the center; spinelets absent from rays beyond outer cribriform organ; scattered among the spinelets are numerous papulæ, especially in the interradial areas; externally these papulæ appear subglobular, and are much larger than the spinelets; epiproctal cone varying in thickness, and from 3 to 5 mm. high.

Marginal plates arching inward, so that contour of body is defined by the inferomarginals when viewed from above, these forming a sloping lateral face to the rays and disk. Superomarginals, 18 or 19 in number from the median interradial line to extremity of ray, nearly quadrate and larger than the lower series, each plate bearing 1 robust, tapering, sharp spinule (or occasionally 2) nearly as long as height of plate, these forming a series at upper edge of plates and decreasing in size toward extremity of ray; terminal plate prominent, notched at inner abactinal edge adjacent to integument, and bearing 5 tubercular spinules, 1 at extreme tip, 1 at either side of end of furrow, actino-lateral in position, and 1 on either side, abactino-lateral in position, placed farther inward; inferomarginal plates longer than high, corresponding to superomarginals in number, and not extending upon actinal surface at all, but forming an angle with it.

Cribriform organs, 3 in each interbrachial arc, placed rather close together, the median largest, having about 20 to 24 lamellæ, each organ with a slight depression down the center.

Adambulacral plates narrow and rather long, conspicuously excavated on furrow margin, adoral end most prominent and surmounted by 2 sharp tapering spinelets, one, slightly curved, usually directed into the furrow, the other often a trifle smaller, either reflected back over the plate or turned aborad; midway between extremities of plates a small, thin, scale-like papilla, with the straight base upon which it is articulated running parallel to the furrow, and having the rounded free edge directed outward. The pit covered by the papilla is in a very rudimentary condition on the proximal plates, and beyond the basal fourth of the ray is absent, the papillæ themselves becoming changed into small lanceolate spinelets, accompanying the 2 other spinelets, so that on the outer half of the ray each plate appears to have 3 spinelets.

Mouth plates prominent, the united pair forming a broad keel; median suture prominent, the companion plates touching at inner and outer ends; inner extremity of the combined pair rounded, with a single, robust, short, conical spinelet at the union of the two, at this inner angle; placed higher up, a curved, compressed, smaller spinelet at either side, on each plate, and between the latter and the margin adjacent to first adambulacral plate 2 semicircular papillæ, the adoral occasionally the smaller, though not conspicuously so.

Actinal interradial areas small and triangular, and covered with a thin skin through which the plates are not discernable until the specimen is partially dried.

Madreporic body large, adjacent to a median cribriform organ.

Color in life: General tint whitish, bluish cast on disk due to viscera showing through integument.

Localities: Type from station 4397, about 200 miles off San Diego, Cal., 2,196–2,228 fms., gray mud.

This species is nearest *Porcellanaster crassus*, which was taken by the Challenger Expedition in 2,335 fathoms in the South Pacific, midway between Sydney and Valparaiso. From this form *tenebrarius* differs in having longer and slenderer rays, more numerous marginal plates, longer spinelets on the abactinal membrane, frequently 2 superomarginal spines, 2 adambulacral spinelets, less well-developed pits and papillæ, and broader mouth plates, which have an additional lateral spinelet.

Two of the specimens regularly have 2 superomarginal spinules, and on a few plates there are 3, forming a linear series.

## Family ASTROPECTINIDÆ Gray, 1840.

### Genus BATHYBIASTER Danielssen & Koren.

*Bathybiaster* Danielssen & Koren, Nyt Magaz. for Naturvidensk, XXVII, 4, 1883, 285; Den Norske Nordhavs-Expedition, 1876–78, Zoologi, XI, Asteroidea, 1884, 94.

### **Bathybiaster pectinatus**, new species.

Rays 5. R = 73 mm.; r = 15.5 mm. R = 4.7 r. Breadth of ray at base, between first and second superomarginals, 16 mm.; midway along ray, 13.5 mm.

Rays moderately elongate, tapering continuously from base to a sharply pointed extremity; interbrachial angles rounded; lateral walls nearly vertical, high; abactinal surface slightly inflated on disk, otherwise plane; actinal surface convex on rays; a low epiproctal elevation.

Paxillæ of abactinal area small, not crowded except at center of disk; arranged in transverse rows at sides of paxillar area of rays; no definite arrangement along median radial line; size decreasing toward ends of rays, and at center of disk, largest paxilla on disk midway to margin, each consisting of 3 or 4 centrally situated, small, cylindrical, round-tipped, membrane-invested spinelets, surrounded by a peripheral series of 10 or 12 slightly slenderer ones, the whole forming a very compact, flat-topped, subcircular, or irregularly elliptical group; small papillæ readily seen in the spaces between the paxillæ, especially on the rays.

Superomarginal plates, 46 in number from median interradial line to extremity of ray, encroaching but slightly upon abactinal area, short, high, and regular, and covered with small subcircular squamules along the median transverse or vertical line, these becoming slenderer and more papilliform toward edges of plate, especially in the fasciolar grooves; at about 1 mm. from upper end of plate an erect, slightly flattened, sharp spinelet attaining a length of 1 to 1.25 mm., and decreasing in length toward tip of ray, the series forming a regular longitudinal series at border of abactinal surface; spinelets much reduced in size on first 2 or 3 plates. Inferomarginal plates corresponding exactly to superomarginals in number and length, and like them covered with squamiform spinelets, which increase in size toward lower end of plate, but are slender and spinuliform in the fascioles; about 1 mm. from upper end of each plate a flattened slender tapering spine, attaining a length of 3.5 mm., the series of which extends the length of the ray, except that it is absent from the first 2 or 3 plates. These spines stand out at right angles to the side of the ray, and are longer than those of the superomarginal series, decreasing, like them, toward the extremity. At a similar distance from the lower end of the plates is another longitudinal series of spinelets, a trifle smaller than the superomarginal series, 1 spinelet to a plate and more or less appressed to the ray, this series extending about ⅔ the length of ray (to 18th inferomarginal).

Adambulacral plates with a prominent angular margin to furrow. Armature of the character common to species of *Psilaster*, rather than that usual to *Bathybiaster:* (1) Furrow series consisting of 8 delicate subequal spinelets, a trifle curved, round-tipped or subtruncate, 2 at either end of the series flattened with sides to furrow, the 4 central ones with edges to furrow; lateral-most spinelets often shorter than the others; (2) actinal surface with 2 longitudinal series of flattened, truncate, or round-tipped spinelets, about 5 to each series, outer spinelets slightly wider than inner and all subequal to furrow series; both furrow and actinal spinelets incased each in a membraneous sheath, thin on furrow series but pulpy and thick on actinal spinelets, especially the outer, which appear in consequence heavily clavate. It is difficult to make out the arrangement of spinelets unless the specimen is dried.

Mouth plates long and narrow; armature consisting of a marginal series of 15 short, regular, slightly flattened spinelets, appressed against a superficial series of 14 heavier, cylindrical, round-tipped or subclavate spinelets, which increase in thickness toward outer end of plate; inner end of combined pair of plates truncate, 2 spinelets at angle slightly larger and heavier than the others, slightly bent at base, and appressed to innermost of superficial spinelets; all incased in membrane, and the armature as a whole distinctly like *Psilaster*.

Actinal intermediate areas small, the plates extending about to 22d inferomarginal or about ⅔ length of ray; plates beset with compact groups of very fleshy, spatulate round-tipped papillæ, which become pressed into various shapes by mutual contact; calcareous spinelet within papilla delicate, oblong, and usually truncate; number of papillæ to each plate varying, and arrangement so compact that if the prevalent slime is thoroughly cleaned off the outlines of the groups in the interradial areas are clearly distinguishable; at outer end of mouth plates a few isolated papillæ which resemble in shape a flattened grain of corn attached by the small end. These groups of spinelets are considered as pedicellariæ by Danielssen and Koren in *B. pallidus*. In the present species the compact grouping suggests pedicellariæ, but I seriously doubt whether they serve any such purpose.

Madreporic body small, broadly oval, situated a little to the outer side of a point midway between center and margin of disk. Striations coarse, radiating from center of larger (adcentral) end.

Locality: Station 4387, off San Diego, Cal. (longitude of Point Conception), 1,059 fms., mud.

While the present species is undoubtedly a *Bathybiaster* in general facies, in the character and armature of the marginal plates and actinal intermediate plates, yet in the armature of the adambulacral and mouth plates it strongly resembles *Psilaster*. The peculiar adambulacral spinelets of *B. loripes* Sladen (from off the west coast of South America near the entrance to the Straits of Magellan) are not even suggested in this species.

### Genus DIPSACASTER Alcock.

*Dipsacaster* Alcock, Asiatic Soc. Bengal, LXII, 1893, 172 (no diagnosis); Ann. N. H. (6) XI, 1893, 87 (*D. pentagonalis* Alcock).

### **Dipsacaster eximius**, new species.

Rays 5. R = 108 mm.; r = 44 mm. R = 2.45r. Breadth of ray at base, 51 mm.; at middle of R, 40 mm.

General form flattened, rays broad, leaf-like in shape, tapering gradually, but with an outwardly curved contour, extremity bluntly pointed; interbrachial angles wide, abruptly rounded; abactinal surface but slightly inflated, a slight depression on interradial lines; actinal surface subplane, tube feet large, with pointed tips.

Abactinal paxillæ very regularly arranged on rays in chevrons pointing toward center of disk, the regularity continuing nearly to the center, but along median radial line a slight irregularity; each paxilla consisting of a high pedicel surmounted by a globular or elongate crown of very numerous, slender spinelets sheathed in delicate membrane, the whole forming a dense glomerular tuft, the central spinelets bluntly tipped, but those on the side mucronate, less crowded, and usually extending in a bristling arrangement down sides of pedicel for some distance. In a dried specimen the centrally situated spinelets are much sharper, due to a shrinkage in the membraneous envelope.

Marginal plates regular and massive; inferomarginals extending laterally beyond superomarginals a distance nearly equal to the width of the latter, thus defining the contour of the body; exposed surfaces of plates separated by remarkably deep fasciolar channels. Superomarginal plates, 32 in number from median interradial line to extremity of ray, slightly wider than long, forming an arched bevel to margin of paxillar area, and confined entirely to abactinal surface, even in the interbrachial arc, where they are shortest and widest; exposed surface, which is slightly tumid, covered with small polygonal granuliform spinelets along transverse median line, these rapidly becoming slenderer at margins of elevated ridge, and finally capillary in the fasciolar grooves. Nearly all the plates bear a tubercular, strongly clavate, knobbed spinelet rather nearer the aboral edge than the center, with occasionally 1 or 2 smaller companions. These do not extend far above the general level of the other spinelets, except in one large specimen. Inferomarginal plates corresponding exactly in number and position to superomarginals; specialized ridge of each plate very high, and tumid; plates forming a broad border to actinal surface, and much wider than long; on lateral end of each plate, that portion forming edge of ray, a transverse series of 4 to 6 stout, tapering, sharp spinules, the uppermost (or that next) longest, these spinules forming an armature on margin of ray; general covering of plate consisting, on actinal surface, of ovate to oblong-lanceolate squamiform spinelets, which become capillary and very sharp in the fasciolar channels; outer end of plate bristling with slenderer, sharper, lancet-like spinelets, those on sides of the broad fasciolar grooves with excessively fine, mucronate tips.

Adambulacral plates massive, with a curved furrow margin; armature consisting of (1) a furrow series of 6 strongly compressed, round-tipped spines, usually standing at right angles to surface of plate, and with their edges to the furrow, the 2 centrally situated longest (3.75 mm.) and bluntest and the rest graduated, the laterals being ⅔ to ¾ as long and more lanceolate in shape. (2) On the actinal surface about 3 irregular longitudinal series of much smaller and slenderer spinelets, which decrease rapidly in size as they recede from the furrow, the series adjacent to the furrow spines consisting of about 3 or 4 spinelets, tapering, pointed, and ½ to ⅔ the length of the longer of the former; the outer 2 series are very irregular, the outermost being smaller than adjacent actinal intermediate spinelets, and between the former and the latter is a narrow zone free from spinelets.

Mouth plates large and prominent actinally, the combined pair broadest at about the middle; armature consisting of (1) a furrow or marginal series of 8 spines, similar in character to median spines of adambulacral furrow series, which begin at about middle of plate and form a fairly straight series to inner angle, increasing in size as they proceed inward, the inner 2 quite broad, flat, and knife-like, and, in common with the others, the edge away from furrow often thinner than that toward it; (2) actinal surface covered with slender, spaced, spinelets, which increase in size toward the suture and inner angle.

Actinal intermediate areas large, the plates arranged in chevrons. The breadth of ray in this species is largely due to the intermediate plates, of which 4 longitudinal series extend over ¼ the length of ray, 3 series slightly over ½, 2 series over ¾, and a single series nearly to tip. Plates strongly carinated, the keel running transversely, each surmounted by a prominent paxilliform tuft of spinelets, of which the peripheral are slender and papilliform, the central much stouter, often clavate, with flattened, flaring pointed tips which appear to be bent outward toward marginal plates; spinelets of the series adjacent to adambulacrals heavier, often subprismatic and square-tipped. In the dry state all the spinelets are much slenderer, and the peripheral ones capillary. Between these actinal paxillæ are fairly deep fasciolar channels.

Madreporic body large (9 mm. in diameter), irregular in outline, situated nearer to center than midway to margin, and hidden by 18 or 19 large paxillæ.

Locality: Type from station 4334, Los Coronados Islands, southwest of San Diego, Cal., 525 fms., green mud.

This species is particularly characterized by its broad rays and disk, and the extensive actinal intermediate areas. It further differs from *D. pentagonalis* and *D. sladeni* of the Indian region in details of armature. The capture of this genus off California is rather surprising.

According to Mr. M. H. Spaulding, the color in life is orange yellow, lighter yellow beneath.

### Genus PERSEPHONASTER Wood-Mason and Alcock.

*Persephonaster* Wood-Mason & Alcock, Ann. N. H. (6) VIII, 1891, 430 (*P. croceus* Wood-Mason & Alcock)

### **Persephonaster penicillatus**, new species.

Rays 5. R = 176 mm.; r = 35 mm. R = 5r. Breadth of ray at base (between second and third superomarginals) 36 mm.

General form flattened; rays long, and tapering from a narrow base, in smaller specimens just a trifle swollen above the base; disk rather small, capable of slight inflation; interbrachial angles rounded; abactinal integument thin, a trifle convex at base of rays, rather sunken in middle of disk; marginal plates conspicuous, armed with stout spines, not encroaching upon abactinal area; no pedicellariæ present; superambulacral plates present.

Abactinal area covered with rather small regular paxillæ disposed in very regular transverse, slightly curved rows on the rays, but not regularly on center of disk; these series rather widely spaced and between them a double row of conspicuous papulæ, which are numerous also on the disk; each paxilla consisting of an elongate, elliptical base set longitudinally with reference to long axis of ray, surmounted by a stout, cylindrical, convex-tipped pedicel which bears a crown of 8 or 10 very slender, tapering, needle-like spinelets, considerably longer than the pedicel, and usually standing upright in a cylindrical coordinate group, highly characteristic; paxillæ largest on proximal radial areas, and, owing to the fact that the spinelets stand close together, appearing widely spaced, the papulæ in alcoholic specimens being very conspicuous, though not large.

Superomarginal plates, 39 in number, from median interradial line to extremity of ray, confined almost entirely to side wall; plates strongly tumid, subquadrate, except in interbrachial arc, where they are much higher than long; abactinal margin slightly arched; no fasciolar furrows between either series; near center of each plate a robust tapering spine (or occasionally 2) much longer than the plate (7 or 8 mm.) and directly obliquely upward and outward, these spines longest at about middle third of ray and decreasing in length very gradually toward its extremity, most of them very curiously bifid for half or two-thirds their length, as if composed of 2 fused spines, and possessing, consequently, 2 closely appressed points; abactinal margin of plate bearing 1 or 2 upright, much shorter spinules (2 to 3.5 mm.), robust, tapering and pointed, 1 often shorter than the other; general surface of the plate bristling with small, spaced, capillary thornlets, very much smaller than the paxillar spinelets.

Inferomarginal plates corresponding in number to superomarginals, to which they are opposite, forming a steep, slightly arched level to actinal area; they are also tumid, especially along the transverse axis the tumidity passing into the upper plate without any conspicuous break at the suture between the two. A few of the proximal plates with a transverse series of 3 stout, tapering, pointed spines, frequently a trifle flattened and bifid like those of upper series; the rest of the plates, including the first 2, bearing 2 such spines, the upper the longer (8 to 9 mm.); toward distal part of ray the lower occasionally much reduced in size, and on some of the plates the upper split to the base, being in reality 2 spines with a common articulating boss; these spines are all commonly appressed to the ray, as in *Psilaster*. General surface of plates bristling with delicate spaced spinelets, which increase in size toward lower end of plate.

Adambulacral plates set obliquely; as a rule broader than long, with a curved furrow margin; armature consisting of (1) a furrow series of 5 or, less commonly, 6 (in smaller specimens, 3 or 4), compressed, rather delicate, slightly curved, blunt spinelets (4 mm.) often capped with a knobby membraneous tip, arranged palmately, and usually graduated in length from the adoral to the aboral end of the series, these spinelets usually radiating stiffly apart; (2) on actinal surface an enlarged, flattened, blunt spinule, frequently with a shallow groove running from tip halfway to base, this surrounded by a variable number of smaller, flattened, blunt, membrane-invested spinelets frequently arranged in 2 longitudinal rows, 3 or 4 in each, the spinule standing on the inner series or between the 2, in which case the spinelets appear to form a wide circle around it; outer spinelets usually much flattened at tip and furrowed lengthwise as if incipiently bifid; in smaller specimens there are but 2 or 3 actinal spinelets and 1 spinule.

Mouth plates elongate, narrow, prominent actinally; interradial length 13 mm.; width of combined plates 5 mm.; at inner angle of the 2 combined plates 2 stout, enlarged, somewhat curved blunt spines, and the whole surface of the plate covered with thick, blunt, short, very robust spinelets which are largest near the inner angle and decrease in size and thickness toward the margin adjacent to first adambulacral; furrow series very angular and consisting of a group of spinelets, about 5 in number, situated at a higher level than the tooth, and continued to the first adambulacral along the excavated, short, free margin in 4 more short pointed spinelets. In a smaller specimen there is a regular and prominent series along the margin of the median suture, with a few slenderer spinelets along the sides, lower down, the actinal surface being very prominent. The first adambulacral forms a short and very wide companion plate.

Actinal interradial areas small; intermediate plates small, extending in a single series to within a short distance of tip; in interradial areas plates arranged in short irregular series extending from adambulacral to marginal plates; irregularly roundish, armed with a group of appressed, rather delicate, often flattened, obtuse, grooved, occasionally bifid spinelets, similar near the adambulacral plates to their outer actinal spinelets and forming thence all the transition between these and the lower spinelets of the inferomarginals; these spinelets all sheathed in membrane, which is frequently swollen at the tip. They frequently stand upright; spinulation by no means dense.

Madreporic body large (7 mm. in diameter), circular to irregularly oval, free, situated nearer margin than midway to center; striations rather fine; ridges narrow, branched, centrifugal.

Color in life, madder brown.

Locality: Station 4380, off Los Coronados Islands, southwest of San Diego, Cal., 530 to 638 fms., gray sand and rocks.

## Family BENTHOPECTINIDÆ Verrill, 1899.

### Genus BENTHOPECTEN Verrill.

*Benthopecten* Verrill, Amer. Jour. Sci., XXVIII, 1884, 218 (*B. spinosus* Verrill).
*Pararchaster* Sladen, in Narr. Challenger Exp., 1, 610, 1885.

### **Benthopecten acanthonotus**, new species.

Rays 5. R=? (tip of all of rays broken); r=9.5 mm. Breadth of ray at base, 10 mm. Length of interradial spine, 12 mm.

Rays narrow, depressed, very gradually tapering, probably very long; disk small, the abactinal surface inflated; along rays the abactinal surface nearly plane; lateral walls low, the rays having consequently a thin, flat appearance; actinal surface convex.

Abactinal surface beset with delicate, rather widely spaced, capillary spinelets, 1 to 2.5 mm. long, with a rugose surface, these decreasing in number and becoming slenderer and shorter as they proceed along the rays, here and there a few longer; on disk about 10 longer spinules (5 mm.), widely spaced; on abactinal surface many pedicellariæ, consisting of 2 opposed semicircular series of short curved spinelets, or more often the spinelets, about 12 in number, forming a circle with points meeting in the center, such apparatus from 0.75 to 1.5 mm. in diameter; spinelets rather numerous on disk and basal portion of rays, decreasing in numbers as they proceed outward; papulæ numerous on disk and extending along rays to sixth superomarginal, being confined to sides of area beyond fourth superomarginal.

Marginal plates confined to side wall of ray, considerably longer than high; upper series apparently set somewhat obliquely as regards the long and dorso-ventral axes. Each superomarginal bearing in the center a long, slender, tapering spine, that of the 3d or 4th plate being longest (8 mm.); 2 or 3 tiny capillary spinelets on adoral half of plate, and 1 or 2 in vicinity of spine. Each inferomarginal also bearing a long slender spine, on a slight boss, directed horizontally outward, the fourth being longest, each about equal to or a shade larger than the corresponding superomarginal spine; a second spinule, ½ to ⅔ the length of the larger, just below it; a few scattered capillary spinelets on the general surface; between lower odd interradial, and first inferomarginal of either ray, and between first and second inferomarginals, a characteristic pedicellarian apparatus, consisting of 2 combs, each of about 9 or 10 curved spinelets, meeting over the suture, the apparatus occupying the whole height of the plate (3 mm.); it sometimes occurs between the second and third plates in addition, or skips the suture between the first and second. On one side of one ray an apparatus occurs also between the 6th and 7th, and 9th and 10th plates, there being also 4 or 5 spines from an adjacent adambulacral entering into the make-up. Dorsal odd interradial plate with a prominent spine, 12 mm. long; the lower with a spinule, about the size of the adjacent inferomarginal spinules.

Adambulacral plates comparatively large, with a slight semicircular prominence into the furrow; armature consisting of (1) a furrow comb of 4 or 5 slightly curved, slender, subcylindrical, blunt spinelets, 3 of which are about equal, the aboral shorter, and when there are 5 the adoral also, these spinelets placed close together, and a wide interval between successive series, the spinelets usually standing vertically; (2) on the actinal surface 2 slender, slightly tapering, blunt spinules in a transverse series, the inner ¾ the length of the outer, which about equals 2 plates in length (3 mm. near base of ray); these spinules are articulated to slight knobs or bosses.

Mouth plates large, convex actinally, and the united pair with a broad furrow margin; in contour the combined pair broadly hatchet-shaped; armature consisting of (1) a furrow series of 4 spines, which increase rapidly in size toward inner angle, where the innermost of 2 companion plates forms 2 prominent teeth, much heavier than the others; (2) on actinal surface 5 spines and spinelets, forming a linear series to outer end of plate, decreasing in size as they proceed outward, the inner spines being stout, cylindrical, and slightly tapering, the outermost slender and much shorter, the intermediate 3 graduated between the extremes.

Actinal interradial areas very small, second adambulacral plate in contact with the first inferomarginal; 2, or at most 3, intermediate plates. A comb of 3 to 7 curved spinelets meets a similar but smaller comb on the inferior interradial marginal plate, forming one of the peculiar pedicellarian apparatuses. On one interradius this is represented by an upright spinule and a rudimentary comb which is turned toward the interradial line.

Madreporic body convex, prominent, circular, with coarse, irregular centrifugal striations; situated about ½ its own diameter from the edge of the interradial plate.

Locality: Station 4387, off San Diego, Cal. (longitude of Point Conception), 1,059 fms., mud.

This species is provided with pedicellariæ on the proximal 2 or 3 inferomarginal plates, and abundantly on the abactinal surface. In Sladen's synopsis of *Pararchaster* (Challenger Asteroidea, 5) the present form would be arranged under B, section a, where also *P. huddlestoni* and *P. violaceus* of Alcock apparently belong, *acanthonotus*, in respect to the inferomarginal pedicellariæ, being nearer the latter form. From this it at once differs in having a profusion of abactinal pedicellariæ, slenderer and smoother marginal spines, a less prominent inferior interradial marginal plate, and a different adambulacral and dental armature. The present species is nearest *pedicifer*, among those described by Sladen, but really does not bear comparison with that form.

## Family PLUTONASTERIDÆ (Sladen) Verrill, 1899.

### Genus DYTASTER Sladen.

*Dytaster* Sladen, Narr. Challenger Exp., 1, 608, 1885.

### **Dytaster gilberti**, new species.

Rays 5. $R = 114$ mm.; $r = 22$ mm. $R = 5.2\,r$. Breadth of ray at base, 22 mm.; at tenth superomarginal, ¼ length of ray, 17.5 mm.

Rays elongate, robust, tapering at first very slightly, then more rapidly, to a pointed extremity; abactinal integument inflated on disk, plane on rays; actinal surface convex; lateral wall of ray vertical on proximal half, gradually arching inward and upward on outer half, so that the marginal plates form a steep bevel; interbrachial arcs rounded.

Abactinal paxillar area covered with small paxillæ without definite order, and rather crowded on disk but distinctly spaced on ray; each consisting of a short pedicel surmounted by short, cylindrical, papilliform, obtusely-tipped, equal-sized spinelets, or the peripheral slightly slenderer; 15 to 20 in number at base of rays, even more on disk, and about 12 to 15 at outer part of ray. These stand vertically, the peripheral series flaring a trifle on disk and basal portion of rays, but all radiate on paxillæ of the outer part of ray. Over most of the ray papulæ may be distinguished between paxillæ.

Superomarginal plates, 50 in number from median interradial line to extremity of ray, nearly quadrate except in interbrachial arc, where they are higher than long; plates confined to side wall, except that the upper end forms a very narrow border to the paxillar area; each plate slightly tumid and bearing a rigid, erect, robust, tapering spine at the abactinal end, about as long as height of plate; general surface of plates covered with very small papilliform spinelets which are slenderer at the edges than in the center; inferomarginals corresponding, plate for plate, with superomarginals, tumid, forming a rounded border to actinal area, and covered, like the dorsal series, with a fine nap-like spinulation, which is coarser and more widely spaced on the actinal surface; in center of each plate a tapering, rigid spine, which stands out at right angles to lateral wall of ray, and is a trifle longer than corresponding dorsal marginal spine; these 2 series very regular and extending the length of the ray the lower on the line between the actinal and lateral faces; on the first 2 superomarginals an additional spine between regular spine and actinal margin of plate.

Adambulacral plates longer than wide, with a slightly curved furrow margin; armature consisting of (1) a furrow series of 10 (8 or 9 sometimes) fragile, slightly tapering, round-tipped, faintly compressed spinelets, which are slightly bent at the base and graduated toward either end of the series; (2) on the actinal surface just behind the furrow series, a longitudinal row of about 9 much shorter, thick, clavate spinelets, and on the outer edge of the plate a series of delicate, slender, tapering, papilliform spinelets which follow the contour of the plate and are smaller than the other series; furrow spinelets about as long as extreme width of plate.

Mouth plates large, prominent actinally, and the united pair broadest at middle, but only slightly, or not at all, narrower at outer end; lateral margins toward furrow slightly excavated, and the end toward actinostome truncate. (Unfortunately the armature in the specimen examined has been largely destroyed.) Marginal series much like that of adambulacral plates, and consisting of about 14 spines, compressed and curiously expanded above the slender base, from this expansion tapering to the extremity; these spines seem to increase in size toward the inner angle, where there are 6 teeth, larger and heavier. General surface of plates covered with small papilliform spinelets similar to those of actinal intermediate plates, these increasing in size and thickness at inner angle.

Actinal interradial areas small, the intermediate plates, which are slightly convex, extending to the sixth or seventh inferomarginal, those adjacent to the adambulacral plates being largest; plates armed with spaced, radiating, small, papilliform spinelets. In a smaller specimen than the type several plates of each area bear a peculiar pedicellarian apparatus consisting of 3 or 4 shorter, thickened, clavate spinelets closely appressed. In the type there are but 1 or 2 to each area.

Madreporic body large, 8 mm. in diameter, situated a little more than half its own diameter distant from margin, and hidden by 40 large ornate paxillæ, which stand flush with the general surface; these paxillæ are larger than any on the general abactinal surface and their spinelets are heavier and more clavate, those situated on the periphery being slenderer, however, and apparently mucronate.

Locality: Station 4397, off San Diego, Cal., 2,196–2,228 fms., gray mud.

This is apparently a very distinct species related to *Dytaster exilis* Sladen, from which it differs in having shorter and broader rays, the sides of which are curiously arched inward on the distal portion; less crowded paxillæ which have a greater number of spinelets; more numerous marginal plates, the ventral series of which do not encroach upon the actinal area to any great extent, and a rather less numerous series of furrow spinelets, which further differ in form.

This species is named for Dr. Charles Henry Gilbert, professor of zoology in Stanford University.

### Subfamily MIMASTERINÆ Sladen, 1889.

#### Genus MIMASTER Sladen.

*Mimaster* Sladen, Proc. Roy. Soc. Edin. XI, 1882, 702; Trans. Roy. Soc. Edin., XXX (ii) 1882, 579. (*M. tizardi* Sladen.)

#### **Mimaster swifti**, new species.

Rays 5. R=114 mm.; r=43 mm. R=2.65r. Breadth of ray at base, between first and second superomarginals, 50 mm.

General form large and robust, much flattened; rays broad at base, tapering evenly to a bluntly pointed extremity which is upturned; interbrachial arcs wide, rounded, but subangular, rather more rounded than in *M. cognatus;* abactinal surface slightly inflated, sunken in interradial areas; actinal surface slightly convex on rays, evidently capable of inflation, especially in actinal interradial areas; marginal plates conspicuous; no pedicellariæ.

Abactinal area more depressed than in either *tizardi* or *cognatus*, and covered with robust, roundish, or subhexagonal, uniform, rather closely placed paxillæ, which are arranged in transverse oblique rows at the sides on the proximal portion of rays, but are without order on distal half and on central portion of disk; paxillæ also forming longitudinal rows on basal portion of rays and largest on radial areas; each consisting of a low stout pedicel expanded at both ends, the summit surmounted by a nearly flap-topped group of about 25 short, robust, round subclavate, granuliform spinelets, those in the center occasionally flat-topped, but usually like the rest, round-tipped; in addition to these about 2 irregular peripheral series of very much smaller lanceolate subpetaloid spinelets placed lower down on the pedicel and appressed closely to bases of outer robust spinelets, so that they are not usually superficially visible; papulæ very numerous, arranged irregularly about the pedicels.

Marginal plates fairly conspicuous, but partaking of the nature of very large paxillæ; a well-defined, narrow, naked groove between superomarginals and abactinal paxillæ; both series with especial raised ridges, crowned with coarse granuliform spinelets, which increase in size toward center of ridge, where they are quite heavy and similar to very much enlarged spinelets of the paxillæ, though more tubercular and pointed; on inferomarginals the spinelets are still thicker and heavier and increase in size toward actinal end of plate; superomarginals, 40–43 in number from median interradial line to extremity of ray, much wider than long and most prominent at middle of ray, where the furrows between them are wider than elsewhere; they encroach upon the abactinal area, forming a well-defined border; inferomarginals corresponding to the dorsal series, and between the 2 series a fairly prominent groove; between inferomarginal spinelets and actinal intermediate plates another groove, for the most part obscured.

Adambulacral plates wide and short and rather closely placed, so that the peculiarly characteristic armature forms a dense mass of spines along margins of furrows; on each plate about 10 stout, subcylindrical, untapered, occasionally slightly compressed, truncate or round-tipped spines, which decrease in size as they recede from the furrow, and are arranged either in 5 longitudinal series of 2 or irregularly on outer half of plate; furrow series commonly oblique, and composed of 3 instead of 2 spines, or 1 may stand on center of margin and 2 just behind it; on outer end of plate 5 or 6 robust, smaller spinelets similar to those of actinal intermediate plates, forming a group about the outer spines, into which they grade in size.

Mouth plates comparatively large, rather prominent actinally, this appearance being accentuated by a depression in the interradial area at their outer end; general surface covered with numerous robust, irregular spinelets, which increase in size and become more compressed toward the free margin of the plate; marginal series beginning at outer (aboral) end, high in the furrow, as rather inconspicuous flattened lanceolate spinelets, which rapidly increase in size toward inner angle, the innermost being much enlarged, that next to it nearly as much, spatulate or hatchet-shaped and directed toward actinostome, which is almost entirely closed by the mouth plates. The latter, as a whole, have a very dense, bristling appearance, like the adambulacral plates.

Actinal interradial areas large and paved with superficially oblong plates, arranged in series running from adambulacrals to marginals, there being 10 in the series opposite the first adambulacral; these plates extending far along ray, but not attaining the tip, the number of plates in the transverse rows rapidly then gradually diminishing; each plate bearing on its convex eminence a group of coarse spinelets, which increase rapidly in size toward the center; peripheral spinelets very unequal, rather slender, but the central ones clavate, bluntly pointed, and similar to the centrally situated spinelets of the inferomarginals.

Madreporic body inconspicuous, situated midway between margin and center of disk, partially hidden by paxillæ; striations fine, but ridges coarse, centrifugal, undulating.

Locality: Station 4253, Stephens Passage, Alaska, in 188 to 131 fms.; rock and broken shells; bottom temperature 40.9°.

This is a distinct and rather peculiar species, differing widely from either *tizardi* or *cognatus* in both the general form, which is flattened, and the spinulation, which is notably coarser and more granuliform on the abactinal surface. The marginal plates are more conspicuous and the furrows between them more marked, while the armature of the adambulacral, mouth, and actinal intermediate plates appears coarser, particularly that of the first 2. The armature of the mouth plates with the spatulate teeth and peculiar furrow series is very characteristic.

This species is named for Lieut. Franklin Swift, U. S. Navy, commanding the *Albatross.*

## Family ODONTASTERIDÆ Verrill, 1899.

### Genus ODONTASTER Verrill.

*Odontaster* Verrill, Amer. Journ. Science, XX, 1880, 402 (*O. hispidus* Verrill).

### **Odontaster crassus**, new species.

Stellato-pentagonal, with distinct rays. R=21 mm.; r=13 mm. R=1.5 r. Breadth of ray at base, 15 mm.

Disk large, rays short and blunt, uniformly tapering from the broad base; abactinal surface slightly inflated on radial areas; actinal area subplane; interbrachial angles very wide, shallow, and obtuse; marginal plates massive, conspicuous.

Abactinal paxillæ large and fairly elevated, arranged very regularly in a medium radial and about 6 parallel rows on either side (at base of radial area); each pedicel surmounted by a radiating group of 15 to 20 slender, tapering spinelets, which are longer than the pedicel or tabulum; papular pores fairly conspicuous, 6 about each plate, absent from interradial area where the spinelets of paxillæ or plates are shorter; basal plates of primary apical system much larger than any of the others; tabulum low.

Marginal plates broad and conspicuous; superomarginals forming a raised border to abactinal area; 17 in number to side of body, or 8 to the ray; interradial plate larger than the others, subtriangular. Superomarginals transversely oblong, wider than high, tumid, covered with granuliform spinelets which are thimble-shaped on margin of ray, but slender around edges of plate. Inferomarginals corresponding to superomarginals in number and position, but a trifle less tumid; granuliform spinulation a little coarser, and heaviest at the outer edge of the plate. Deep grooves, subfasciolar in form, separate the plates of both series. The lower odd interradial plate is not so large as the upper; both, however, reach the marginal sutural groove.

Adambulacral plates short and rather wide in proportion; armature consisting of 2 (less commonly 3) terete, tapering, bluntly pointed spinelets on the furrow margin, one slightly smaller than the other; on actinal surface 6 or 7 similar spinelets which diminish in size as they recede from the furrow, and usually disposed in 3 more or less regular longitudinal series, 2 spinelets to each, the outermost about the size of adjacent actinal intermediate spinelets; other adambulacral spinelets conspicuously longer.

Mouth plates with a movable recurved, conspicuous, lanceolate spine which has an obtuse inner and a sharp hyaline outer tip; 1 to each pair of plates; this spine rather broad actinally, not much compressed, and as long as the interradial dimension of the plates; a line of about 5 furrow, and another of 5 or 6 actinal spinelets, the latter crowded by the hyaline spine and extending along either side of it, diminishing in length outward; both furrow and superficial spinelets terete, pointed, very similar to adambulacral spinelets.

Actinal interradial areas large; plates squarish, in 6 regular chevrons and an odd plate adjacent to marginal interradial; plates bearing a group of 5 to 12 radiating, stout, short, pointed spinelets, shortest on margins of plate, occasionally forming a fairly ornate rosette.

Madreporic plate midway between center and inner edge of interradial plate; shape very broadly oval; striations coarse, irregular.

Locality: Station 4313, vicinity of San Diego, Cal., 92 fms., gray sand, broken shells.

This species is even more robust than *P. robustus* Verrill. The marginal plates are fewer and the odd interradial larger. The armature of the marginals is apparently more granuliform, the actinal intermediate plates more numerous, and the adambulacral armature is more robust. There are 2 instead of 4 or 5 furrow spinelets.

## Family PSEUDARCHASTERIDÆ, new.

=Pseudarchasterinæ Sladen, Challenger Asteroidea, 109, 1889, as amended by Verrill, Trans. Conn. Acad., X, 1899, 187.

### Genus PSEUDARCHASTER Sladen.

*Pseudarchaster* Sladen, Narr. *Challenger* Exp., 1, 617, 1885.
*Astrogonium* Perrier (non Müller and Troschel), Exped. Scientif. Travailleur et du Talisman, Echinod., 1894, 338.

The name *Astrogonium*, employed by Perrier and a few other writers for Sladen's genus *Pseudarchaster*, was originally proposed by Müller and Troschel (System der Asteriden, 1842, 52) and included 4 genera, *Hippasteria* Gray, *Goniaster* (Agassiz), *Pentagonaster* Gray, and *Tosia* Gray. The genus was thus a composite group without any type, and may be considered as a synonym of any of the foregoing genera, all of which are now recognized. The transferring of the name to a well-known group, none of the species of which was known to Müller and Troschel, is contrary to the simplest and most commonly accepted usage in matters nomenclatural. *Astrogonium* is forever a synonym.

### **Pseudarchaster alascensis**, new species.

Rays 5. R=99 mm.; r=34 mm. R=2.91 r. Breadth of ray at base 40 mm.; at middle, 15 mm.

Rays rather well-developed, abruptly and arcuately tapering at base, then very gradually to the blunt extremity; interbrachial arcs wide and rounded; abactinal area subplane, only a trifle inflated on center of disk; actinal area slightly inflated.

Abactinal paxillæ crowded, fairly regular, largest in proximal radial regions, very crowded and small at ends of rays, where only the median radial series attains the ocular plate, but the 2 adradial series very nearly reach it; 1½ to 2 paxillæ correspond to each marginal plate; armature of paxillæ consisting of 1 or 2 central, polygonal or subprismatic, robust, elongate granules, heavier at tip than base and either flat or convex-tipped, surrounded by about 5 or 6 similar granuliform spinelets, alternating with very much slenderer, prismatic, pointed spinelets; or the 5 to 7 or 8 robust spinelets may form a central group, often in an ornate rosette, surrounded at a slightly lower level by the slender spinelets, the latter standing between the heavy spinelets, however. Spinelets intermediate between the 2 sizes occur on the periphery of some of the paxillæ.

Superomarginal plates, 50 in number from median interradial line to extremity of ray, much wider than long, widest in interbrachial arc and forming an even bevel, which is more arched on outer part of ray; these plates covered with a very regular hexagonal granulation, which is coarser at the outer (lateral) end of the plate, and distinctly though not distantly spaced, a peripheral series of smaller closer granules being clearly distinguishable; granulation of these plates coarser than that of the paxillæ. Inferomarginals corresponding exactly to superomarginals and forming a similar border to their area, covered with a coarse hexagonal granulation, which increases rapidly in coarseness toward outer edge of plate, where many of the granules flare at the tips and are somewhat squamiform. In the interbrachial arc the plates bear a median transverse series of 4 or 5 flattened, sharp lanceolate, appressed spinelets, which becomes reduced to one beyond the middle of the ray.

Adambulacral plates with an angular furrow margin bearing a palmate series of 5 tapering, more or less compressed spinelets, the median (or adoral admedian) the longest and most compressed; tips rounded; the lateral spinelets often with flat side uppermost; furrow series continued along adoral and aboral margin of plate in 3 or 4 spaced, much smaller, papilliform spinelets; on the actinal surface 2, or occasionally 3, enlarged, robust, pointed spinules, standing in a transverse, oblique, or longitudinal series, between them and the furrow series a semicircular row of 3 or 4 shorter, blunt, papilliform spinelets, very irregular, and on outer part of plate several smaller, clavate, spinelets; exclusive of the furrow series about 22 spinules and spinelets to each plate, the outermost very irregular in distribution, and on distal part of the ray showing a tendency to group themselves about the 2 or 3 larger spinules.

Mouth plates remarkable for their bristling armature; rather narrow, especially at the outer ends, and appearing quite distinct from one another; 1 enlarged tooth at inner angle of the combined plates, and the 3 adjacent spinelets decreasingly graduated on either plate, the next 4 longer and subequal, the outer slightly shorter than the 4; on actinal surface a dense mass of blunt cylindrical spinelets, which are rather long and slender on the inner end of the plate, but short, papilliform, and clavate on the outer part, the one kind passing insensibly into the other; the smaller spinelets form 2 regular rows on the outer part of the plate, but in one interradius there are 4.

Actinal interradial areas large, the intermediate plates extending as far as the tenth inferomarginal; plates armed with spaced papilliform spinelets, those in the center robust and clavate, with slightly flaring tips bent outward, the peripheral smaller, round-tipped, occasionally subprismatic, very unequal and irregular, and radiating over narrow fasciolar grooves between the plates; these grooves lead from the inferomarginal fascioles to those between the adambulacral plates, following an irregular course. A number of scattered plates have one of the central spinelets considerably enlarged and pointed.

Madreporic body small, situated ⅓ the distance from center to inner margin of superomarginal plates; striations very irregular.

Locality: Station 4236, near Yes Bay, Behm Canal, Alaska, in 147 to 205 fms., rocks, coarse sand; bottom temperature, 42.8°.

This species is characterized by well-developed post-adambulacral fascioles. It is probably most nearly related to *Pseudarchaster pretiosus* (Doederlein) from Japan (Tokyo and Sagami bays 20–30 meters) and may prove identical when a comparison of specimens is made. The original description (Zool. Anz. 1902, 326) is rather too short and incomplete to determine details of ornamentation.

### **Pseudarchaster pusillus**, new species.

Rays 5. R = 32 mm.; r = 14.5 mm. R = 2.2 r. Breadth of ray at base, 17.5 mm. A prevalent variation has still shorter rays: R = 28 mm.; r = 15 mm.; and another R = 29 mm.; r = 17 mm. R = respectively 1.86 r and 1.7 r. In the last specimen, breadth of ray at base = 18.5 mm.

This species differs from the foregoing in having shorter and broader rays, larger disk, smaller paxillæ, which, instead of being crowded, are distinctly spaced, giving an open appearance to the abactinal area; conspicuous papulæ; much narrower and less numerous superomarginal plates, which consequently do not encroach so much upon the abactinal area, especially on rays, leaving a broad paxillar area; more prominent spinules on inferomarginals. The most striking differences, however, are in the proportions of the rays and disk, and in the character of the paxillæ, which are very evident when this species is compared with equal-sized specimens of the foregoing.

Paxillar area either plane or slightly convex; paxillæ arranged in regular chevrons, well spaced, and consisting of an ornate crown of 4 or 5 robust, clavate, or low pestle-shaped granules, alternating with or surrounded by a regular series of slender papilliform spinelets; lateral paxillæ much smaller; at about middle of ray 7–9 longitudinal series of paxillæ and the area 2 to 2.5 times as broad as a superomarginal plate. In general form the species varies from stellate to stellato-pentagonoid with deeply arcuate sides.

Superomarginals, 25 in number from median interradial line to extremity of ray, forming a steeply arched bevel to border; 1 or 2 of the granules near outer border of plate much enlarged, subtubercular, the others distinctly spaced, hexagonal, decreasing in size toward inner edge. Inferomarginals with a widely spaced subpapilliform granulation, and a median transverse row of 4 prominent sharp spinules which are reduced to 2 on outer half of ray.

Adambulacral plates with a palmate furrow series of 4 or 5 terete, papilliform spinelets, blunt, and graduated to either end of the series; on actinal surface a semicircle of unequal "barley-corn" spinelets on border of plate, surrounding a similar but enlarged central spinule, often curved. The outer plates of the series have the spinelets frequently arranged in 2 rows, and there are 2 spinules enlarged.

Actinal intermediate plates extending halfway to tip of ray, and fasciolar, as are the marginal plates; they bear a small group of widely spaced ovoid granules, which become slender when dry. An enlarged spinule is also frequently present.

Mouth plates similar to those of *alascensis;* a median odd spine at inner angle, and the furrow series angular, rising slightly toward the peristome; angle slightly nearer the inner or suture than the outer or aboral end of the margin, and the 8 spinelets graduated toward it, decreasing rapidly in length, so that the median spinelets of the series are quite small and inconspicuous; on actinal surface a superficial series of 8 spinelets graduated in length from outer to inner angle, and bordering the suture, and a similar series of 3 or 5 merging into it from the aboral margin. Some specimens have an intermediate series.

Madreporic body fairly conspicuous, situated midway between center and inner edge of superomarginals. It is relatively larger and more conspicuous than in *alascensis.*

Color in life: Abactinal surface dull coral red, rather deep, varying to maroon in small specimens, in which case the abactinal paxillar area is much darker than marginal plates, which are bright coral red; actinal surface of inferomarginal plates pinkish buff; actinal intermediate areas grayish, often tinged with pink; tube feet olive buff to raw sienna. A second phase is of the same general tint but much paler.

Locality: Station 4423, between Santa Barbara and San Nicholas Islands, 216 to 339 fms., shells, black pebbles, green sand.

This species might naturally be considered the young of the foregoing, but I have young of *alascensis* and they are widely different, having longer and narrower rays, very wide superomarginal plates, larger and crowded paxillæ which are essentially like those of the adult, less numerous and less prominent inferomarginal spinules, and no actinal interradial spinules. In fact the last are scarce in fully matured individuals of *alascensis.* Minor differences occur on the madreporic body and adambulacral armature. The facies of the two forms is entirely different, owing to the character of paxillar area and the proportions. Though perfectly distinct, I believe the species are rather closely related.

## Family GONIASTERIDÆ Forbes, 1840 (restr.).

### Subfamily GONIASTERINÆ Verrill, 1899.

### Genus TOSIA Gray.

*Tosia* Gray, Ann. N. H., VI, 1840, 281 (*T. australis* Gray).

### Tosia leptocerama, new species.

Pentagonal. R=63 mm.; r=44 mm. R=1.43 r. In smaller examples (e. g., R=38 mm.; r=22 mm.) the contour is often stellato-pentagonoid, R equaling 1.73 r; but usually the form is pentagonal.

Disk remarkably thin for the genus, the marginal plates being small, elongate, and inconspicuous; sides of body only 3.5 mm. high; edges of disk curved inward gently toward the interradius; superomarginals not in contact at tips of "rays;" radial areas of abactinal surface and center of disk somewhat inflated; actinal area subplane, or sunken, making the inferomarginals appear as a narrow ridge, the body being not more than 1.5 mm. thick in the median interradial area.

Marginal plates elongate and, owing to the thinness of the disk, rather small; except for the first 2 or 3 plates, the members of the 2 series alternate. Superomarginals, 14 in number from each interradial line to extremity of series, or 28 to each side of disk, about as high as broad, and much longer than high, except at the end of the series, where they are shorter; these plates forming a narrow border to the abactinal area and covered with a rather uniform, dense, polygonal granulation, a peripheral series being readily distinguishable; the outer plates with a small naked area on abactinal face, bearing 1 to 3 small, 2-jawed pedicellariæ, larger than the granules; these pedicellariæ present also on the inner plates, but there only a narrow area about each is left free by the granules; lower margin of each superomarginal angular. Inferomarginals 16 to the ray or 32 to a side, and much wider than high, encroaching farther upon actinal area than do the dorsal series upon the abactinal; in the middle of the actinal surface a small naked area, increasing in size toward outer end of series, which bears 1 to 3 small, 2-jawed pedicellariæ, but slightly larger than the granules. There is considerable variation as to the extent of the naked areas, which are much reduced on some specimens. Granulation of inferomarginals similar to that of superomarginals.

Abactinal surface covered with spaced, low, tabulate plates, arranged with great regularity in a radial series, which is largest, and numerous other parallel series, decreasing rapidly in size toward the margin, where the plates are small and more crowded; in center of disk plates are arranged without order, and are more or less irregular in a narrow interradial area, which is free from papulæ. Bases of plates of radial areas, when viewed from the inner side, in a prepared specimen are substellate, regularly with six truncate or blunt processes, a shallow sulcus running from the center of the plate to each interradial angle. The plates are entirely free from one another, those of the radial and either adradial series being lengthened transversely, the others rounder. In the vicinity of the marginal plates they become more crowded and lengthened longitudinally. In the center of disk the plates are roundish, and in the narrow interradial area quadrate, roundish, lozenge-shaped, or, near margin, oblong. In the proximal portion of the radial areas, small secondary plates or paxillæ, with narrow ossicle-like bases, are interspersed rather irregularly, but form a fairly regular series between the radial and either adradial row of plates. The low tabulum surmounting each plate is slightly convex, and bears a central group of robust, flat-topped, quadrate or polygonal granules (about 10 on radial plates) surrounded by a peripheral series of smaller, square-tipped, flattened regular granules. Nearly all the plates bear 1 or 2 delicate pedicellariæ with wide-spatulate jaws, higher than the granules. At the edge of the disk where the plates are very irregular only the marginal series of granules may be present, on account of the compression of the plate. The papulæ are conspicuous on account of the open character of the tabulate armature, and are numerous. The abactinal membrane is rather flexible, the plates not being in contact.

Adambulacral plates nearly quadrate, with a straight furrow margin; armature consisting of a furrow series of 8 or 7 untapered, flattened, square-tipped spinelets about half as long as the length of the plate, subequal or slightly shorter at either end, united at the base by a membrane, very regular and standing parallel; on the actinal surface 2 irregular longitudinal series of smaller granules, the inner well spaced from the furrow series, as in *Mediaster*, and consisting of 3 or 4 compressed, square-tipped, sharp-edged granules, larger than those of the outer series, which are very irregular in distribution, 8 or 9 in number, and similar to, but a trifle larger than the actinal intermediate granules; there are sometimes 2 irregular rows of these smaller outer granules; at adoral end of inner actinal series a pedicellaria with 2 broadly spatulate jaws, slightly larger than the granules of the series, which the pedicellaria greatly resembles when the jaws are closed; at tip of "ray" 4 or 5 spinelets in the furrow series, and on the actinal surface a blunt, prominent tubercle, surrounded by several granules, this tubercle grading into the granules of the inner actinal series. The pedicellaria persists to within 2 or 3 plates of the tip.

Mouth plates triangular, with a longer furrow margin than the edge adjacent to first adambulacral; furrow series consisting of 12 or 13 spinelets similar in character to those of adambulacrals, but increasing in size toward inner angle, where there is an oblanceolate, blunt, flattened or compressed tooth, the other spinelets square in section or slightly compressed; on actinal surface a linear series of low, squarish granules adjacent to the median suture, several others along the aboral edge, and 2 or 3 intermediate between the superficial and marginal series.

Actinal interradial areas very extensive; intermediate plates quadrate, roundish, or irregular, those adjacent to the adambulacrals much larger than any of the others, and usually oblong in shape, the short end toward furrow; plates arranged in rows parallel to furrow, considerable irregularity existing; plates covered with uniform, hemispherical, beadlike granules slightly spaced; pedicellariæ similar to those of adambulacral plates scattered here and there, especially near the furrow, but their numbers subject to great variation.

Madreporic body irregular in outline, larger than any plates, situated $\frac{1}{3}$ distance from center to margin; slightly convex and the striations, of medium coarseness, radiating from the center, irregularly.

Color in life: Vermilion, yellowish on actinal surface.

Locality: Type from station 4378, off Point Loma, near San Diego, Cal., 376 to 594 fms., green mud and sand.

This is a variable species as regards the minor details of ornamentation and contour of body. The younger specimens are not so noticeably thin and flat, and the marginal plates are more normal. The secondary abactinal plates are wanting in young specimens, and in examples $\frac{3}{4}$ the size of type vary considerably in numbers. The pedicellariæ appear to be numerous on the abactinal surface of all the specimens.

This is in some respects a very abnormal *Tosia*, especially in the character of the abactinal plates, and in the presence of secondary smaller ossicles intercalated between the larger primary plates. The small marginal plates give it a very peculiar appearance, and, combined with the thinness of the body, form characters which will readily separate this species from any other now referred to the genus.

I found a very flat *Myzostoma* (*M. fisheri* Wheeler) in an interradial portion of the cœlomic cavity of one specimen.

## Subfamily MEDIASTERINÆ Verrill, 1899.

### Genus MEDIASTER Stimpson.

*Mediaster* Stimpson, Jour. Boston Soc. Nat. Hist., I, 1857, 490, pl. 23, figs. 7–11 (*Mediaster æqualis* Stimpson).

### **Mediaster tenellus**, new species.

Rays 5. R = 58 mm.; r = 19 mm. R = 3r. Breadth of ray, between first and second superomarginals, 20 mm.; at middle of ray, 7 or 8 mm.

General form flattened; disk large; rays fairly long and slender, tapering abruptly at base, then more gradually; interbrachial arcs very wide, and rounded; abactinal surface inflated on radial areas, sunken on interradial areas, the rays especially being convex; actinal surface considerably inflated on disk; marginal plates small, confined nearly to sides of body.

Abactinal area covered with ornate, regularly spaced paxillæ, largest in a regular median radial series, decreasing thence toward tip of rays and margin of disk; paxillæ of median radial series elongated transversely, the others roundish, the former bearing on the periphery of the pedicel or tabulum 15–17 prismatic, blunt spinelets, as long as or slightly longer than the lesser dimension of the tabulum and decidedly longer than is usual in this genus; in the center 6 or 7 irregular, prismatic, pointed granules, much shorter than the peripheral spinelets; ornamentation of the other paxillæ differing only in having less spinelets and granules. At the tip of the ray the plates lose their tabulate character. Many of the paxillæ bear on the edge or nearer the center, a small upright pedicellaria, whose 2 jaws are slightly higher than wide and very much larger than the central granules. Papulæ are numerous, single, especially conspicuous on radial areas because the paxillæ are spaced. They are absent from the very tip of the rays and a small interradial triangular area adjacent to the median marginal plates.

Marginal plates rather smaller than in any other species of the genus, and throughout most of the ray the superomarginals are confined to the side wall; 30 in number from median interradial line to extremity of ray, thin, slightly longer than high throughout most of ray, and forming a slightly arched, steep bevel to side of body; first plate conspicuously higher, or wider, than long, and longer on inner than lower edge. General surface covered with evenly spaced thimble-shaped granules which increase in size toward the center of each plate, the peripheral being rather small and pinched. A few plates bear pedicellariæ similar to those of the paxillæ. Inferomarginals beyond the second plate alternating with superomarginals and wider than high, forming a narrow border to the actinal area, thin, slightly longer than broad, and the upper edge angular, like the lower edge of the superomarginals; granulation rather coarser than that of superomarginals, square or prismatic, and very few pedicellariæ on the series.

Adambulacral plates rather regularly quadrate and remarkable for the long furrow spinelets, of which thére are 5 in each series, strongly compressed, regular, round-tipped, the adoral slightly shorter than the other 4, these spinelets reaching nearly across the furrow and tapering slightly as regards their thickness, the tip being often beveled; on the actinal surface a longitudinal series of 3 spinelets, the central longest and about ¾ the length of the furrow spinelets, the series standing midway between furrow margin and outer margin, upon which are 3 or 4 less regular granules similar to those of the actinal intermediate plates; first plate and a few others with a peculiar pedicellaria on actinal surface consisting of 2 or 3 slender upright strap-shaped jaws, occasionally faintly spatulate, nearly as high as the inner actinal series.

Mouth plates slightly convex actinally and the furrow armature consisting of 8 spinelets, similar in character to those of the adambulacral plates; the 2 inner larger than the others, and those between inner and outer members of the series slightly shorter, or, in other words, graduated in size from the middle toward either end of the series; on actinal surface a number of elongate granules, and one of the peculiar pedicellariæ, the latter situated near the median suture at about middle of plate.

Actinal interradial areas large, the plates extending to ninth inferomarginal or about half the length of ray, arranged quite regularly in series parallel to the furrow, slightly convex and armed with 6–8 spaced, elongate, prismatic granules, usually forming an ornate rosette.

Madreporic body convex, oval, situated nearer center than midway to margin; striations coarse, undulating, interrupted, centrifugal.

Locality: Station 4427, off Santa Cruz Island, Cal., 376 to 510 fms., black mud, broken stones.

This species is remarkable for the small marginal plates, the high, slender, pedicellariæ of the actinal surface, and for the unusually long furrow spinelets. The peripheral spinelets of the abactinal paxillæ are also more elongate than is usual in the genus. *Mediaster tenellus* is therefore far removed from *æqualis*, the type of the genus, and probably deserves to be set apart in a different subgenus, for which the name *Isaster* of Verrill might prove available. The present form approaches the genus *Nymphaster* in the actinal pedicellariæ, but does not have the marginal plates of that genus, and the abactinal plating and pedicellariæ are not those of *Nymphaster*. *Tenellus*, however, must be regarded as an aberrant member of *Mediaster*, probably nearer *Nymphaster* than any of the other species.

## Subfamily HIPPASTERIINÆ Verrill, 1899.

### Genus **HIPPASTERIA** Gray.

*Hippasteria* Gray, Ann. N. H., VI, 1840, 279 (*H. europæa* Gray=*H. phrygiana* Parelius).

*a.* Marginal plates well developed, subquadrate, not separated by encroaching abactinal or actinal intermediate plates; granules fairly or quite smooth.

*b.* Pedicellariæ shorter and higher. Dorsal surface very spiny; as a rule no pedicellariæ on marginal plates; actinal pedicellariæ with oblong or subquadrate jaws; actinal intermediate plates not conspicuously tuberculate. .......................................................................................... *phrygiana* *bb.* Pedicellariæ low, long; a well-developed pedicellaria on the proximal superomarginals, and on most of the inferomarginal plates; papulæ conspicuous, bag like; actinal intermediate plates tuberculate; actinal pedicellariæ very low, long........................................................................................*heathi.*

*aa.* Marginal plates weak, irregular, oval or elliptical, the proximal usually separated by encroaching plates from the dorsal and ventral surfaces; actinal pedicellariæ high, rather delicate, flaring at base and with narrow curved serrate tips; granules rugose or denticulate.....................................................*californica.*

### **Hippasteria heathi,** new species.

Rays 5. $R = 78$ mm.; $r = 39$ mm. $R = 2r$. Breadth of ray at base 42 mm.

General form, robust; disk large; rays short, tapering from a wide base to a blunt, recurved extremity; abactinal surface considerably inflated; a well-defined interradial sulcus leading from marginal plates ¾ of distance to center of disk; interbrachial arcs wide, shallow, rounded; actinal area subplane.

Abactinal surface beset with widely spaced, robust, rigid, tapering, upright, bluntly pointed spines, 3.5 or 4 mm. in length; 1, or rarely 2, to the larger rather widely separated primary plates, the median radial and either adradial series of spines extending to tip of ray, but very irregularly; the other spines too irregularly distributed to form rows. Scattered all over abactinal surface many sessile, long, low, bivalved pedicellariæ with smooth edges to the jaws; pedicellariæ 1.5 to 3.5 mm. in length, 1.5 mm. wide, and a trifle less than 1 mm. high; rest of surface covered with spaced, small spherical, acorn-shaped and thimble-shaped granules of various sizes, immersed in and covered by a soft membrane which obscures the outlines of the plates; whole abactinal surface crowded with conspicuous obtuse, bag-like papulæ about 2 mm. in length, the base being surrounded by a collar (the rim of the pore); these papulæ especially numerous in the proximal radial regions.

Marginal plates not particulary conspicuous. Superomarginals 15 in number from median interradial line, slightly convex, and confined to side of body; first plate larger than the rest, which are rather longer than high except at end of ray, where the reverse is true; upper edge of the series largely obscured by abactinal membrane; each plate on proximal half of ray (first to fifth or sixth) bearing a sessile bivalved pedicellaria and in addition 1 to 4 spines like those of abactinal surface, edge of plate (excepting usually the upper) being armed with 1 or 2 interrupted series of stout conical granules of various sizes; outer plates of series with a single central spine, and marginal granules in 1 or 2 irregular series. Inferomarginals corresponding in number to superomarginals and opposite them in proximal third of ray, but alternate on outer part; they encroach somewhat upon the actinal area, the lower margin being obscured on the disk by the membrane covering the general surface of the plates. Nearly all the plates bear a bivalved pedicellaria and, in addition, on the first 2 plates of the series a circle of 4 or 5 spines, like the superomarginal spines surrounding it, and on the rest 2 or 3, these situated on the aboral side of the plate. There are also on the border of each plate numerous stout conical granules mixed with small ones, the former occasionally having 1 or 2 enlarged into conical spinules, intermediate in size between the spines and larger granules. The pedicellariæ of the marginal plates are exactly like those of the abactinal surface.

Adambulacral armature, consisting of 2 heavy cylindrical or slightly compressed blunt furrow spines, the adoral a trifle the smaller on outer half of ray; and on actinal surface, a transverse series of 2 similar spines, rather more tapered, the outer the shorter, occupying all the exposed surface, the outer spine reduced in size on the first few plates. Margin of plate surrounded by conical granules, 1 or 2 on the outer edge larger than the rest.

Mouth plates small, narrow; furrow margin very extensive; furrow spines 4, similar to those of adambulacral plates, the innermost slightly longer and most compressed; on actinal surface opposite the outer furrow spine 1 compressed spine nearly as long, and on the inner part of the plate usually another, considerably shorter, connected with the first by a linear series of several spaced, unequal, conical granules, which are continued beyond the outer spine to the end of the plate, there forming a group rather than a row.

Actinal interradial areas large, 3 series of intermediate plates extending to the fourth inferomarginal, 2 to the fifth, and 1 to the ninth; each of the plates adjacent to the adambulacrals bearing a large, sessile, bivalved pedicellaria, 4 mm. in length, similar to those of dorsal surface, placed usually obliquely crosswise; numerous other interradial plates also with a pedicellaria, usually somewhat smaller; plates also armed with 1 or 2 conical spinules or tubercles standing on the edge, often on either side of the pedicellaria, in line with a peripheral series of large and small hemispherical or acorn-shaped granules; plates without pedicellariæ bearing 1 or 2 unequal thimble-shaped or acorn-shaped spines surrounded by a peripheral series of small granules, with 2 or 3 here and there larger than the others; all the actinal interradial spines shorter than the marginal.

Madreporic body small, circular, situated slightly nearer center than midway to margin; striations fine, ridges rather wide.

Locality: Station 4239, Clarence Straits, Alaska, 206 to 248 fms., coarse sand, rocky; bottom temperature 49°.

This species is named for Dr. Harold Heath, associate professor of zoology in Stanford University.

### **Hippasteria californica**, new species.

Rays 5. R = 73 mm.; r = about 35 mm. R = 2r approximately. Breadth of ray at base, about 40 mm.

Disk very broad, rather thinner than usual in this genus; rays tapering from a broad base arcuately to a bluntly pointed extremity; interbrachial arcs very wide, shallow, and rounded; abactinal surface considerably inflated, especially in the interbrachial region adjacent to margin; rays recurved, and in some specimens the interbrachial arcs appearing angular from this cause.

Abactinal surface armed with rigid upright spines and spinules much as in *phrygiana*, but the spines rather shorter and less numerous, on some specimens scarcely more than tubercles; pedicellariæ numerous, shorter and higher than in *phrygiana*, very broadly spatulate, with strongly denticulate rims; the granules, which are fairly smooth and not very prominent in *phrygiana*, in this species are multifid or denticulate, very rugose in appearance, and prominent, the investing membrane being thin and ineffective as a covering; papulæ numerous, vermiform, absent from a narrow interradial area.

Marginal plates small and rather thin, irregularly oval or elliptical, longer than high except at end of ray, where the two dimensions are nearly equal. Superomarginals, 12 in number from interradial line to extremity of ray, confined entirely to side of body and rather inconspicuous, very irregular as to shape, successive plates frequently separated by small intermediate encroaching abactinal plates; each plate with a tapering blunt spine articulated rigidly to a central boss and a marginal series of rugose granules, there being also 1 or 2 smooth subconical granules on the general surface; occasionally, also, a pedicellaria just beneath the spine. Inferomarginals very similar to superomarginals, of the same number, but not opposite to them; similarly armed, but the pedicellaria very rare; actinal intermediate plates encroaching and separating most of the proximal inferomarginals.

Adambulacral armature consisting of (1) a single blunt spine, usually considerably compressed and somewhat tapering, situated on the angular furrow margin, with occasionally a shorter, similar adoral companion, or, 1 or 2 very short spinelets or compressed granules on either side of the single spine; (2) on the actinal surface a more robust, upright, tapering, blunt spine situated just external to the furrow spine, and just adoral to this usually a medium-sized pedicellaria, one jaw of which is broad serrate and rather deeply scoop-shaped, closing over the other, which is smaller, thicker, and not hollowed out; margins of plates bordered with the peculiar rugose granules, a few of which also stand on the surface.

Actinal intermediate areas large, 2 series of plates extending ¾ the length of ray, and a single series nearly to tip; most of the plates with a central high pedicellaria of a peculiar shape so far as this genus is concerned; jaws rather thin and wide at base, abruptly narrowing into the distal portion, which bends toward the other jaw and has a truncate, serrated edge; pedicellariæ thus in form more like those usual to the *Goniasterinæ*, though much larger; plates bordered with a series of rugose granules, with several of the same size on general surface, where there are besides these a number of considerably larger, smoother, subconical granules, immersed like the rest in thin membrane. On some specimens these are almost wanting, on others they are prominent and compressed, sometimes subtubercular and thimble shaped.

Mouth plates prominent actinally; furrow spines 5 or 6, considerably compressed, the inner spines the larger and heavier; on actinal surface an incomplete series of three spines, parallel with the furrow, usually 1 near the inner angle and 1 or 2 near the outer end of the furrow series; remainder of surface covered with rugose spinelets, often curiously compressed or pinched, with denticulate edges, these forming a row on the median suture margin, and another adjacent to first adambulacral.

Madreporic body large, irregular, much as in *phrygiana.*

Locality: Type from station 4429, off Santa Cruz Island, Cal., 506 to 680 fms., green mud, black pebbles, broken stones.

## CRYPTOPELTASTER, new genus.

Most nearly related to *Hippasteria*, from which it differs in having the whole abactinal surface covered with numerous flat, irregularly circular, oval, elliptical, triangular, polygonal, quadrate and boomerang-shaped scales, attached to the plates and smaller secondary ossicles by the middle of the under surface, leaving free the edges of the scales, which frequently overlap. These scales, though robust enough, have a very peculiar chaffy appearance and completely hide the outlines of the underlying plates, the larger of which bear each a short conical spine. Numerous long, low, bivalved pedicellaria on abactinal surface; marginal plates tumid, covered with irregular, polygonal, plate-like scales or granules and bearing a central tubercular spine; no odd interradial; adambulacral plates with 1 actinal and 2 stout furrow spines, flattened or flaring at the tips, occasionally grooved or incipiently bifid or trifid; sometimes a large sessile bivalved pedicellaria replacing the furrow spines; actinal interradial areas extensive, the plates covered with plate-like granules and central tubercles and tubercular granules; series adjacent to adambulacrals bearing large bivalved pedicellariæ. Type, *Cryptopeltaster lepidonotus*, new species.

### **Cryptopeltaster lepidonotus**, new species.

Rays 5. R = 105 mm.; r = 51 mm. R = 2. (+)r. Breadth of ray at base, between second and third superomarginal, 50 mm. or less, according to degree of inflation of abactinal area.

Disk large; rays fairly well developed, tapering to a blunt tip, which is much recurved; interbrachial arcs very wide, and rounded; abactinal area much inflated on rays and radial areas of disk, also in each interradius adjacent to margin; actinal area subplane.

Abactinal surface covered with peculiar, flattened, scale-like granules, which are irregularly circular, oval, elliptical, triangular, polygonal, quadrate, boomerang-shaped, and of several other shapes which defy description, of greatly varying sizes, so closely placed that they often overlap a trifle; attached to the larger plates of the skeleton by the middle of their under surface, being entirely free around the edge; or, forming the flaring summit of many variously sized ossicles packed between the regular rows of rather widely separated primary plates. These scales might be likened to the flaring head of a wire nail. The exposed surface of many is raised into a low tubercular eminence. Primary plates superficially marked by a robust, low, conical spine, about the base of which is a series of elongated granules often curiously excavated on the edge, these spines decreasing in size toward edge of disk and end of ray, and grading into broad conical granules in the interradial areas, where the primary plates are small, closely packed, and the secondary ossicles nearly wanting; on the ray a radial and 3 or 4 parallel series of spines on either side, all low (1.5 mm.), scarcely more than tubercles; long, low, bivalved pedicellariæ (2.5–4 mm. in length) numerous on abactinal surface, especially on interradial areas, center of disk, and proximal radial areas, each surrounded by a series of quadrilateral granules of various sizes; papulæ numerous, especially on rays, but apparently absent from a very small interradial area adjacent to marginal plates.

Superomarginal plates rather small, irregularly quadrilateral, higher than long in middle of interbrachial arc, but longer than high throughout most of ray; on account of the inflation of the abactinal surface these plates confined to side of ray, and the abactinal edge of each arched; each plate tumid and bearing in the center a rigid acorn-shaped or conical tubercular spine slightly larger than those of the median radial series; general surface of plates covered with polygonal granules similar to those of abactinal surface, the peripheral scales being elongated, a number on each plate convex or low conical. Superomarginals 26 or 27 in number from median interradial line to extremity of ray. Inferomarginals slightly larger, and more nearly square on the ray where the upper series is oblong; in general each inferomarginal corresponding to a superomarginal, similarly covered with granules (most of which, exclusive of the peripheral series, are prominent or subconical), and bearing 1 or 2, rarely 3, tubercular spines in the center, all short and stubby; smaller plates intercalated here and there in the inferior series, apparently due to injury of some sort.

Adambulacral plates nearly square, each bearing 2 large, heavy spines on the margin, usually compressed and truncate at tip, or occasionally flaring, and, again, grooved at tip and incipiently bifid or trifid; a large sessile bivalved pedicellaria occupying furrow margin of first plate, extending whole length of plate; a similar pedicellaria occurring frequently on other plates of the series; on actinal surface of each plate a robust spine just behind the furrow spines, which it greatly resembles, though a trifle shorter; this spine either bluntly tipped, compressed, or curiously wrinkled, and reduced to a small conical tubercle, a mere specialization of one of the granules, on those plates in which a pedicellaria replaces the furrow series; general surface of plate covered with irregular plate-like granules similar to those of the actinal intermediate plates.

Mouth plates fairly large; furrow spines 3, flattened, the inner flaring and hatchet-like though irregular; an odd spine at inner angle of the combined plates; one much smaller spine on actinal surface adjacent to outer furrow spine; surface of plate covered with 2 longitudinal (interradial) rows of flattened plate-like granules which diverge and partially surround the actinal spine, being much smaller toward the inner angle; these granules quadrate or pentagonal, and their surface sunken a trifle, then raised in a small low boss in the center.

Actinal interradial areas large; a single row of intermediate plates extending very nearly to tip; a second series ⅔ the length of ray; a third very nearly as far; a fourth nearly half, and so on; plates adjacent to adambulacrals largest, elongated transversely, and more regular than the others, though far from regular themselves; most of them bearing a long bivalved sessile pedicellaria (4 mm.) not more than 0.5 mm. high, placed transversely or obliquely transversely, forming a very conspicuous series on either side of the adambulacral series and extending about half the length of ray; flat, oblong, or irregular granules surrounding them, the whole somewhat convex in appearance; a number of the granules with a subconical prominence in the center, the other intermediate plates bearing a central conical tubercle, surrounded by several low conical granules which grade into the flatter, plate-like granules toward the periphery of the plate, these granules resembling those of the abactinal surface in shape but not free on the edges.

Madreporic body fairly large, somewhat convex, irregular in outline, situated nearer center than midway to margin; striations deep, irregularly interrupted; anal opening surrounded by a cluster of bead-like granules.

Color in life, scarlet vermilion.

Locality: Station 4430, off Santa Cruz Island, 197 to 284 fms., black sand, pebbles.

## Family SOLASTERIDÆ Perrier, 1884.

### Genus **LOPHASTER** Verrill.

*Lophaster* Verrill, Amer. Journn. Sci. and Arts, 3d ser., XVI, 1878, 214 (*Solaster furcifer* Düben and Koren).

### **Lophaster furcilliger**, new species.

Rays 5. R = 70 mm.; r = 16 mm.; R = 4.38r. Breadth of ray at base, 18 mm.

Rays rather long, tapering from a narrow base very gradually to pointed extremity; disk rather small; abactinal surface convex on rays and disk; interbrachial angles narrow and acute; ambulacral furrow very wide and open.

Abactinal surface beset with paxillæ which have rather long (2–3 mm.) slender pedicels, with a capitate summit beset with numerous (20 or even more) long, delicate, glassy spiculiform spinelets, flattened, flaring and bifurcate at the tip, arranged in a glomerular tuft on the subglobose tip of the pedicel; these spinelets about 1 to 1.2 mm. in length and radiating in all directions; paxillæ largest on disk, decreasing in size toward end of ray; papulæ numerous.

Superomarginal paxillæ well developed and larger than abactinal except on outer ⅔ of ray, where the two are about equal; well spaced and with stouter and longer (3.5 mm.) pedicels than the abactinal paxillæ, the spinelets being usually trifurcate. Inferomarginal paxillæ still stouter, about 23 in number from median interradial line to extremity of ray.

Adambulacral plates short and broad, with wide intervals between successive plates, the suture being wider than the length of exposed surface of plate; furrow series consisting of 4 spinelets at base of ray, which are soon reduced to 3, then to 2 beyond middle of ray, and finally to 1; these spinelets rather long, delicate, skin-covered and united for ⅓ or ½ their length by a web; when there are 4, they are graduated in length toward the adoral, which is shortest; when there are 3, the middle is usually longest, and commonly the adoral when there are 2; the separate series well spaced from one another and the spinelets as long as or even longer than the width of the plate; on the actinal surface a series of 4, 3, or 2 longer and more robust, tapering, pointed spinelets, disposed in an oblique transverse series, and decreasing in length as they recede from the furrow, skin-covered, often having lateral expansions, and the bases united by membrane; when there are 3 or 4 spines, the outer is usually much shorter than the rest.

Mouth plates fairly large, spade-shaped, and prominent actinally; median suture wide, roofed with membrane; furrow spinelets 7 or 8, long, skin-covered, united for about ⅓–½ their length by a web, increasing very slightly in length toward the innermost, which is rather more robust than the others; near the middle of the suture margin a group of 3 or 4 much slenderer spinelets, which are shorter than those on furrow.

Actinal interradial areas very small, containing small intermediate plates, which bear small paxillæ, and, widely spaced, extend along the ray, here and there, between the inferomarginal and adambulacral plates nearly to tip of ray.

Madreporic body small, convex, situated about midway between center of disk and margin.

Locality: Station 4425, between Santa Barbara and San Nicholas islands, 1,084 to 1,100 fms., green mud, sand, globigerina.

## Family KORETHRASTERIDÆ Danielssen and Koren, 1884.

### Genus PERIBOLASTER Sladen.

*Peribolaster* Sladen, Narr. Challenger Exp., I, 616, 1885 (*P. folliculatus* Sladen).

### **Peribolaster biserialis**, new species.

Rays 5. R=20 mm.; r=7.5r. R=2.6r. Breadth of ray at base, 8.5.

Abactinal surface convex, rather flexible; form stellate; rays rather short and robust, wider than high, tapering, the outer part somewhat slender and often recurved; interbrachial arcs acute, the rays being constricted slightly at the base; edges of ray rounded, due to inflation of abactinal integument; tube feet strictly biserial.

Abactinal plates stellate, and imbricate by means of rather long rod-like intermediate ossicles, forming a very open reticulate skeleton with wide interspaces for the papulæ; no serial arrangement to the plates, but the papular areas generally quadrate; each plate conspicuously convex and surmounted by a brush-like fasciole of about 5 delicate, glossy, sharp spinules about 3 mm. long, which are united into a compact group by a membrane, sometimes the spinules radiating a trifle; spinules decreasing in length toward tip of ray, but increasing slightly toward margin; papulæ long and conspicuous, 6 or 7 to an area.

Actinal surface paved with 2 longitudinal rows of band-like plates, which are comparatively wide and short; the adambulacrals bordering the furrow, and external to them a series of equally regular plates, probably the inferomarginals; adambulacrals much wider than long and separated by prominent sutures; each plate with a transverse series of 3 prominent spinules, sheathed individually in membrane, which extends beyond the tip in a short sacculus; each spinule surmounting a slight boss on the plate, one situated on the furrow margin, another on the extreme outer margin, and one exactly midway between the two; inner spinule 2 mm. long, and the other 2 successively slightly longer and stouter.

Inferomarginal (?) plates a trifle longer than adambulacrals and not quite so wide, so that they do not exactly correspond to the latter, even though the sutures are not so prominent; surface of each plate actinal in position and slightly convex, and the outer, lateral end bearing a prominent membrane-invested spinule, 3–3.5 mm. long, which superficially appears to stand in a linear series with the adambulacral armature; inferomarginal spinules, of which about 35 can be counted to the side of each ray, decreasing in size toward extremity, where both marginal and adambulacral plates with their armature are very small; about 10 lateral cruciform plates immediately adjacent to (above) inferomarginals, forming perhaps the superomarginal series.

Mouth plates very prominent actinally, the exposed surface rising toward the median suture; the combined pair thus with a very prominent but rounded beak about midway between inner and outer angles, or a little nearer the outer; margin of each plate rounded, but somewhat angular where the furrow edge merges with that turned toward the mouth; general form of mouth plates strongly recalling that of *Pteraster* and allied genera, the median beak on the actinostomial margin, in line of the median suture, being present; armature consisting of 4 marginal spinules, that nearest the adoral beak being largest, the third situated on angle between furrow and actinostomial margin at a lower level in the furrow than the other spinules, and often directed across or down into the furrow, while the others are reflexed; fourth spine commonly standing somewhat on actinal surface; all enveloped in membrane, which is prolonged beyond the tip in a sacculus.

Actinal interradial areas very small; apparently no actinal intermediate plates.

Madreporic body of medium size, situated about midway between center of disk and margin, irregularly circular in outline, with coarse, often branching, centrifugal ridges and narrower striations; anal opening somewhat eccentric, surrounded by low, cylindrical, granuliform spinelets; ambulacral furrows wide; actinostome not very wide, often completely closed over by mouth plates; tube feet with a button-like terminal disk.

Locality: Station 4410, between Santa Catalina and Santa Barbara islands, 178 to 195 fms., fine gray sand and rocks.

## Family PTERASTERIDÆ Perrier, 1875.

### Genus PTERASTER Müller and Troschel.

*Pteraster* Müller and Troschel, System der Asteriden, 1842, 128 (*Asterias militaris* O. F. Müller).

### **Pteraster jordani**, new species.

Rays 5. R = 75 mm.; r = 37 mm. R = 2r. Breadth of ray at base, 37–42 mm. Thickness of ray at base, about 28 mm.

Form stellate, depressed; abactinal surface of rays and disk convex, actinal surface subplane; edges of ray rounded; rays tapering, with fairly straight sides, bluntly pointed, though sometimes swollen near tip and the extreme tip recurved, giving an entirely different appearance; interbrachial angles obtuse; a well developed lateral fringe present.

Supradorsal membrane rather thin, with no deposits of calcareous matter; paxillar spines very prominent; 2 spines to each paxilla (sometimes 1 or 3), 1 considerably longer than the other, protruding 3 or 4 mm. above general level of the membrane, but carrying the latter with it; pedicel very low, and the spine correspondingly rather longer than usual in this genus; fine criss-crossing muscle fibers exceedingly abundant, and the summits of the paxillar spines connected by faint muscular bands, which are nearly invisible in the type specimen but show with some distinctness in a smaller example; in the irregular meshes thus formed 1–3 large spiracula, these often absent; oscular orifice rather small.

Adambulacral plates with a transverse series of 3 spines and 1 spinelet, united by a web; inner member of the series quite small and situated slightly aborad from the others; the next three 4 or 5 times longer, and increasing slightly in size outward, united by membrane nearly to their tips, which are capped by a membraneous sacculus; outer spine close to the corresponding actinolateral spine, to which it is united by membrane; aperture papillæ prominent, jawbone-shaped, free on the aboral margin. On a smaller specimen the inner small spinelet is absent, and in the type it is sometimes absent, especially in plates beyond the middle of the ray.

Armature of mouth plates consisting of a marginal series of 4 spines and spinelets, the inner long and slender, the next nearly as long, and the outer 2 much shorter; inner 3 united by membrane, and usually also the whole 4, but the outermost, which is shortest, sometimes standing alone; on the actinal surface commonly 1 long, slender spine about the size of the inner marginal, with which it stands in a linear series, directed over the outer end of the plate, this spine entirely free from the others.

Actinolateral spines rather short, the 9th or 10th the longest; membrane thin, and forming a lateral fringe with a slightly undulating edge, the spines not protruding beyond its margin; width of membrane only a trifle greater than that of furrow.

Ambulacral furrows broad; tube feet in 2 rows.

Locality: Station 4354, vicinity of San Diego, Cal., 642 to 650 fms., green mud.

Named for Dr. David Starr Jordan, president of Stanford University.

### Genus HYMENASTER Wyville Thomson.

*Hymenaster* Wyville Thomson, The Depths of the Sea, 1873, 120 (*H. pellucidus* Thomson).

### Hymenaster quadrispinosus, new species.

Marginal contour stellate. R=24 mm.; r=12 mm. R=2r. Breadth of ray at base, 14 mm.; interbrachial angles wide and very obtuse; rays tapering evenly to a pointed, recurved extremity, the lateral margins being nearly straight; abactinal surface nearly plane; actinal surface very convex, due to recurving of rays.

Supradorsal membrane rather thin, but tough, with a satiny luster; spinelets of paxillæ about 3–5, protruding but slightly, forming subconical prominences; muscle fibers very difficult to discern; spiracula not numerous, scattered over the proximal portion of radial areas, of fair size and each surrounded by a definite white ring; oscular orifice large; valves triangular, with a truncate summit, however; spinelets about 11 to each valve, the 7 central ones subequal, the laterals graduated; membrane of valves rather thick; on base of each valve at either side a well-defined triangular spiracular area about ⅓ the height of the longer spines, containing 15–30 spiracula; in the membrane between adjacent valves numerous spiracula, which extend nearly to the distal edge of the valves; supradorsal membrane slightly raised along interradial lines.

Ambulacral furrows very wide and open, widest in the proximal third; armature of adambulacral plates consisting of an obliquely transverse series of 4 sharp tapering hyaline spinelets, graduated from the outer, which is longest and thickest, to the inner, which is about ⅓ the length of the outer; just external to the latter and in line with the series is the broadly ovate, round-tipped aperture papilla, fitting tightly over the corresponding segmental aperture like a valve, the base of this papilla abruptly narrowed for articulation to the plate; the first papilla much larger than the rest and lying in the actino-lateral membrane.

Mouth plates rather narrow, with a prominent actinal surface and a rounded margin for the combined pair; armature consisting of (1) 3 short, subequal, tapering spinelets on the lateral margin, and (2) on the actinal surface near the median suture 2 rather prominent tapering hyaline spines, the inner standing fairly on the margin, and longer than the outer, which is in line with it. The inner spine is sometimes directed over the actinostome and might be considered as a furrow spine.

Actinolateral spines delicate and well spaced, tenth from the mouth longest; about 30–32 in all, the outer very short on account of the tenuity of tip of ray; no lateral fringe unless right at tip.

Color in alcohol rose pink; in life probably a deeper rose madder or scarlet.

Locality: Station 4387, off San Diego, Cal. (longitude of Point Conception), 1059 fms., mud.

## Family ZOROASTERIDÆ Sladen, 1889.

### Genus ZOROASTER Wyville Thomson.

*Zoroaster* Wyville Thomson, The Depths of the Sea, 151, 1873 (*Z. fulgens* Wyville Thomson).

*a.* Abactinal skeleton compact; papular areas small; 4 longitudinal series of plates between the adambulacral and inferomarginal series on proximal third of ray; spinulation not conspicuously sacculate .......................... *ophiurus.*

*aa.* Abactinal skeleton rather open, with comparatively large papular areas; only 3 longitudinal series of actinal intermediate plates on proximal third of ray (or if fourth is present it is very rudimentary and bears no spines); spinulation conspicuously sacculate.

  *b.* Size large; abactinal papular areas large; skeleton between median radial and superomarginal plates irregular, reticulate; spinelets with thick, soft, saccular sheaths; abactinal plates granular.................................. *sacculatus.*

  *bb.* Size medium; a needle-like central spine on all plates except in the adradial series; abactinal plates covered with capillary spinelets .......................................................... [illegible]

### Zoroaster ophiurus, new species.

Rays 5. R=140 mm.; r=10 mm. R=14 r. Breadth of ray at base, 11 mm.

Disk small and convex; rays very long and slender, tapering from a narrow base to an attenuate extremity; abactinal surface of rays strongly convex, with a fairly prominent median radial ridge; spinelets and spinules exceedingly delicate; pedicellariæ of abactinal surface prominent.

Plates of abactinal surface of disk rather convex, the primary radials and basals most prominent, these covered with delicate and slender sharp spinelets, about 1 mm. in length, distinctly spaced, among which are scattered numerous forficiform pedicellariæ, longer than the spinelets, and of course much more robust; median radial series of plates more prominent than the rest and each bearing on a central prominence a thimble-shaped tubercle; abactinal and lateral faces of the ray gradually confluent by a well-rounded margin, the superomarginal plates not being prominent in any way; between superomarginal and adambulacral plates 5 longitudinal series of exactly similar plates—an inferomarginal and 4 actinal intermediate series—and all precisely similar to the superomarginals; on outer portion of ray the intermediate series successively reduced to 3, 2, and finally, at end of ray, to 1; each of these plates, including the 2 marginal series, bearing a very slender, delicate, sharp spinule, which increases in length toward the furrow, that on the proximal superomarginals being 2 mm. in length and that nearest the furrow on the same transverse series nearly 4 mm.; general surface of the plates covered with very delicate, short, spaced, often curved spinelets, and having 1 or 2 rather prominent pedicellariæ to each plate, forming fairly regular longitudinal rows along the ray, between successive series of plates; median radial plates bearing 2 to 5 pedicellariæ each; papulæ inconspicuous, 1 or 2 to the pore, usually 1; papular areas very small.

The prominent adambulacral plates with a transverse series of 3–5 spinelets; the inner 2 short, stout, and pointed, and borne on the furrow projection; the innermost with a terminal membranous expansion bearing 6 or 8 pedicellariæ of graduated sizes, the second with 1 similar, much larger pedicellaria, or occasionally 2, near the base of the spinelet; the next, or first actinal spinelet, longer and slender and pointed, the 2 following being successively shorter; on outer part of ray only 2 actinal spinelets commonly present, and the second furrow spinelet often missing. The alternate non-prominent plates have a small furrow spinelet, bearing 1 or 2 small pedicellariæ, situated near the adoral edge, and on the actinal surface a transverse row of 2 spinelets very similar to those of the prominent plates; a large pedicellaria sometimes stands at the outer end of the series.

Madreporic body convex, subtubercular, circular, situated 7 mm. from center of disk.

Locality: Station 4387 off San Diego, Cal. (longitude of Point Conception), 1,059 fms., mud.

### MYXODERMA, new subgenus.

Differs from typical *Zoroaster* in having smaller median radial plates, either cruciform or substellate, and irregular adradial plates which are not compactly placed, but form an irregular, open, subreticulate skeleton at the base of the ray, leaving comparatively large papular areas, which have 2–4 papulæ. There are 3 series of intermediate plates between the inferomarginal and adambulacral series, instead of 4 as in *Zoroaster*. Spinelets (and in type species the spines also) invested with a pulpy sacculus, giving them a very robust, flabby, papilliform appearance. Type, *Zoroaster* (*Myxoderma*) *sacculatus*, new species.

### **Zoroaster (Myxoderma) sacculatus**, new species.

Rays 5. R = 200 mm.; r = 17 mm. R = 11.7 r. Breadth of ray at base, 22 mm.

Disk convex; rays subcylindrical, robust, but slender, tapering from a narrow base to a pointed extremity, which is capped by a large terminal plate; all the plates spiniferous; membranous investment of spines and spinelets, thick, fleshy, and saccular; interbrachial angles very acute. In life the whole animal is very slimy.

On the proximal portion of the rays and on disk the abactinal skeleton is comparatively very open and subreticulate; plates cruciform and stellate, with fairly long processes by which they are joined, leaving extensive subquadrate papular areas; plates becoming less markedly lobed on the sides and ventrolateral region of the ray, and the papular areas then reduced in size as in typical *Zoroaster;* primary basals and radials stellate, their processes touching and slightly overlapping, and joining also the irregularly cruciform under basals; papular areas very wide in proportion to the plates, quadrate or triangular in shape; disk plates bearing a number of short, compressed, blunt spinules, articulated to rounded bosses on the surface. In life they, as well as the general surface of the plates, are covered with a thick, fleshy, rather viscous membrane. Prominent pedicellariæ thickly scattered over the disk, principally in the papular areas; abactinal skeleton of rays very open, and subreticulate, the lateral and actinal more nearly as in typical *Zoroaster;* median radial series of plates fairly regular, cruciform or rarely stellate, a trifle larger than the superomarginal plates, which are also cruciform, but shorter; between these two series, on either side, a very irregular longitudinal series of smaller triradiate or cruciform plates, which articulate and usually imbricate with the processes of the radial and superomarginal series, either directly or by means of small intermediate ossicles, producing the peculiarly large abactinal papular pores characteristic of this species. Superomarginal series perfectly regular, the cruciform plates a little wider than long; between this series and the adambulacral plates an inferomarginal and 3 intermediate series present at base of ray (reduced to 2 on outer part and to 1 at tip), the plates forming regular transverse series as well as longitudinal; plates overlapping more and more as they near the furrow, so that the papular areas are successively reduced until absent toward the outer part of ray between the intermediate plates. On the outer portion of the ray the open character of the abactinal skeleton is largely lost, the adradial plates becoming more regular as the ray increases in tenuity. All the plates of the ray bearing a prominent spine, which is rather shorter on the adradial than on either the radial or superomarginal series; these spines terete or slightly compressed, tapering and pointed, and increasing in size toward the adambulacral plates, those of the inner actinal intermediate series being about 6 mm. long; median radial plates often bearing an accessory spinule, their spines about 3 mm. long, tapering and blunt; general surface of abactinal plates covered with small granules, widely scattered, but on the superomarginals spinelets begin to appear, which increase in number and in length toward the furrow; fair-sized pedicellariæ numerous on abactinal surface, but greatly decreasing in number on sides and actinal surface of ray; these usually found about the border of the papular areas. Whole surface of the plates, granules, spines, and spinelets covered with a thick, fleshy or jelly-like membrane, which is decidedly slimy in life; this investment conspicuous, especially on the spinelets; each spinelet with a thick, clavate, saccular sheath, with a rounded tip much larger than the spinelet, which is entirely hidden. On account of the size of this pulpy sheath the spinelets appear closely crowded. The larger spines also similarly invested, and appearing heavy and flattened; papulæ numerous, conspicuous, vermiform, 4 or 5 to an area on abactinal surface and 1 or 2 on sides of ray; papulæ usually longer than the abactinal spines; abactinal membrane frequently much wrinkled in alcohol, doubtless due to loss of water.

The prominent adambulacral plates have a conspicuous furrow keel. Their armature is as follows: (1) on tip of furrow projection a short terete spinelet, often curved, bearing a large pedicellaria with curved jaws, and 2 or 3 smaller companions, the latter sometimes absent; (2) on the exposed surface of the plate a transverse series of 3 or 4 slightly curved, tapering, pointed spinelets, which diminish in size as they proceed outward, the inner 2 subequal and standing on the actinal surface of the furrow keel; 1 or 2 shorter spinelets form an accessory transverse series along the adoral margin of the plate; these actinal spinelets invested in a thick pulpy membrane, which entirely obscures the outer spinelets of the series, giving them a blunt, clavate, papilliform appearance. The alternate non-prominent plates have a small spinelet on the margin bearing a pedicellaria (smaller than that of adjacent plates), and on the actinal surface, in 2 transverse rows, are 4 spinelets, about the size of the smaller spinelets of adjacent plates, and heavily invested with membrane.

Madreporic body small, convex, situated near entrance to the interbrachial sulcus; anal opening considerably to one side of center; terminal plate large, notched toward the terminal radial plate, wider than the ray just adorad, and bearing several small spines about the edge.

Color in life, a "salmon" buff.

Locality: Station 4517, Monterey Bay, Cal., 916 fms., mud.

### **Zoroaster (Myxoderma) evermanni,** new species.

Rays 5. R = 140 mm.; r = 11 mm. R = 12.7r. Breadth of ray at base, 11 mm.

Rays very long, and tapering gradually from a narrow base to a pointed extremity, which is capped by a small terminal plate; disk convex, the abactinal surface considerably higher than carinal ridge of ray; interbrachial angles very acute, the rays being frequently constricted at base.

Primary radial and basal plates of disk stellate with short processes; papular areas smaller than in the preceding species; primary apical plates bearing a central, short, pointed spine articulated to a prominent boss on the plate, and the general surface armed with much shorter, delicate spinelets also articulated each to a tiny granular prominence, and encased in a pulpy, thick membrane which covers also the general surface of the plates; spinelets well spaced, but on account of the pulpy sheath appearing fairly close together; median radial series of plates substellate, slightly larger than superomarginals, and each bearing a central boss, surmounted by a prominent, tapering, sharp spine about 4 mm. in length; plates of either adradial series smaller and irregular, but not so much so as in the preceding species; papular areas, though comparatively large, smaller than in the preceding species, because the radial plates are relatively larger; a regular series of superomarginal plates, which are prominent and mark the boundary between abactinal and lateral faces of ray; between this and adambulacral series 4 longitudinal rows of regular plates, including an inferomarginal and 3 series of actinal intermediate plates, the latter reduced to 2 series at about middle of ray, and to 1 on outer fourth; each marginal and intermediate plate bearing a central, slender, sharp spine articulated to a boss, spines slenderer and longer than the median radial series, and forming regular transverse as well as longitudinal rows, decreasing very slightly in size toward the furrow. General surface of all the plates beset with spaced capillary spinelets of extreme delicacy, which are sheathed in pulpy membrane, so that in life they appear robust, papilliform, and blunt; the larger spines likewise sheathed, but the membrane thinner; abactinal surface with pedicellariæ about as long as the spinelets, usually 1 to each papular area, forming thus 2 longitudinal series between carinal and superomarginal plates; less numerous on the sides of ray; papulæ 3 or 4 to the area, except below inferomarginals and near end of ray, where there are usually but 1 or 2.

Prominent adambulacral plates with a slight prominence into furrow; armature consisting of a transverse series of 4 or 5 spinelets, the inner 2 standing well within the furrow, the innermost slightly the shorter and bearing a bunch of 4 or 5 small pedicellariæ; the outer 2 or 3 standing on the actinal surface and graduated in size outward; the inner of these much longer than the second furrow spinelet and very slender; the next slightly shorter, and the outermost similar to the delicate capillary spinelets of the intermediate plates. The alternate, nonprominent plates have a very small spinelet on the furrow margin near the adoral border, and on the actual surface 2 spinelets in a transverse series, the outer capillary, the inner very similar to the longest spinelet of the prominent plates. All the spinelets invested in membrane.

Madreporic body convex; situated near summit of interradial sulcus.

Locality: Station 4400, between San Diego and San Clemente Island, 500 to 507 fms., green mud.

This species is named for Dr. Barton Warren Evermann, assistant in charge, Division of Scientific Inquiry, U. S. Bureau of Fisheries.

## Family BRISINGIDÆ G. O. Sars, 1875.

### Genus BRISINGA Asbjørnsen.

*Brisinga* Asbjørnsen, Fauna Litt. Norvegiæ, andet Hefte, 1856, 95. (*Brisinga endecacnemos* Asbj.).

### Brisinga exilis, new species.

Rays 10. R=250 mm.; r=10 mm. R=25r. Breadth of disk, 20 mm.; thickness, 4 mm.; breadth of ray at base, 5 mm.; at widest part of genital inflation, 6 mm. (R varies to 180 mm.).

Rays delicate, long, and slender, with a very attenuate, lash-like outer portion; costal ridges very prominent, narrow, well spaced, 10 or 11 in number, extending a little less than ¼ length of ray; disk small and thin, with a delicate abactinal membrane.

Abactinal membrane of disk containing rather rudimentary, spaced, delicate plates which bear 2 to 5 short, sharp, delicate spinelets disposed in a row or irregular group, and covered with a delicate membranous sheath; abactinal surface of disk low, not raised above level of rays; interradial plates small, slightly keeled, narrow, the rays fragile, and the abactinal membrane thin and devoid of prickles; costal ridges 9–11 in number, rather widely spaced, narrow, irregular, and prominent, composed of elongate plates which imbricate by their ends; these plates, in the proximal portion of the genital area at least, bearing 1 or 2 rather stout subconical prickles, and in life having each costal ridge overlaid by a cushion of pedicellariæ; ridges corresponding to about every other adambulacral plate, and between them, corresponding to the alternate plates, a transverse, prominent saccular band of pedicellariæ, these continued throughout the ray, beyond the costal region, with about 1 to every adambulacral plate; all prominent and in alcoholic specimens difficult to distinguish from the costal ridges unless one feels for the plates of the latter.

Adambulacral plates longer than wide and wider than high, with an excavated or concave furrow margin; armature consisting of (1) a very delicate furrow spinelet at adoral end of plate, surmounting a slight boss and armed with a terminal pad of minute pedicellariæ; (2) on actinal surface, rather nearer aboral margin than center of plate, a much stouter and longer spine (about 4 mm.), covered with a rather thick membranous sheath, closely beset with pedicellariæ; (3) ankylosed to the side of every other adambulacral plate a small lateral plate bearing a spine about 7–9 mm. in length, which, like the others, is sheathed; actinal adambulacral spine shorter on plates, opposite to which there is a lateral spine.

Actinostome 12.5 mm. in diameter; mouth plates small, the combined width of the 2 plates being about equal to breadth of furrow at its mouth; plates with no conspicuous lateral processes into furrow; armature consisting of (1) a rather prominent, but slender and delicate, marginal spinelet situated at angle between furrow and actinostomal margins; (2) on actinal surface near center a still longer spinule, and on furrow margin, very near the first adambulacral, a very small spinelet sometimes present, all bearing subterminal groups of pedicellariæ.

Locality: Station 4398, off San Diego, Cal., 620 fms., green mud, rocks.

### Genus FREYELLA Perrier.

*Freyella* Perrier, Première note, préliminaire sur les Echinodermes recueillis par le Travailleur et le Talisman, Ann. des Sciences Nat., Zoologie, XIX, 1885, 5.

### **Freyella fecunda**, new species.

Rays 13. R = 330 mm. (approximately); r = 13.5 mm. R = approximately 25r. Diameter of disk over all, 27 mm.; of elevated portion, 24 mm.; thickness of disk, 5 mm. Diameter of ray at base, 6 mm.; at widest portion of genital inflation, 25 to 75 mm.; from base, 7.5 mm.

Rays very long, narrow, tapering gradually; a trifle narrower at base than throughout the very extensive genital region, which is not inflated; rays subcylindrical at base, depressed on genital region; latter extending nearly half length of ray; beyond genital region abactinal membrane collapsed upon ambulacral ridge, which can be seen through the translucent membrane; disk fairly large, abactinal surface slightly raised above level of base of arms; lateral spines of arms long and slender.

Edge of disk rounded and somewhat undulating in outline; abactinal membrane very tight and beset with equally spaced, small, terete, blunt spinelets, those about anal opening a trifle longer than the others; shape of spinelets due to a membraneous sheath, the calcareous portion acicular; interradial plate rather high and narrow, confined to side wall of disk, inconspicuous; abactinal membrane of rays rather thin and papery, the plates being superficially invisible except in a thoroughly dried specimen; plates rudimentary, very thin, imbricating at least in the median radial region, irregular in outline, and consisting of a single layer of delicate calcareous network. In the extensive genital region the abactinal membrane is beset with minute, evenly spaced prickles, which are incased in membrane, giving them a superficially blunt appearance; these prickles much smaller than those of disk, and 1 or 2 to each plate, commonly 2; on outer part of genital region, where the plates are not so closely placed, the prickles are more widely spaced, and many of the plates are without them. Indistinct bands of microscopic pedicellariæ, from each lateral and adambulacral plate proceeding toward median radial line, where they break up; on the semi-transparent membrane of outer half or two-thirds of ray (beyond genital region), where there are no prickles, these bands of pedicellariæ more conspicuous, and extending entirely across abactinal surface, but frequently more or less irregular on median keel of ray; extending upward from the rudimentary marginal or lateral plates are a few plates stouter than the other abactinal ones, forming thus the rudiments of costal ridges.

Ambulacral plates longer than high, and in basal portion of ray nearly as wide as long; armature consisting of (1) 2 delicate spinelets situated at aboral end of the slightly excavated furrow margin, these sheathed in membrane and bearing numerous minute pedicellariæ; spinelets fairly long and reaching more than halfway across the wide furrow; throughout greater part of ray but 1 spinelet on the furrow; (2) on actinal surface near aboral end 2 spines forming an oblique transverse series with the furrow spinelet, the inner the shorter, about twice as long as the furrow spinelet, the outer from 2 to 2½ times longer than the inner; outer spine about 10–11 mm. long; all sheathed in delicate membrane, forming a blunt saccular tip, all beset with microscopic pedicellariæ, and all uniformly slender and sharp; (3) partially fused to lateral face of alternate adambulacrals a lateral plate, bearing a long, slender spine (13 mm.) sheathed in membrane bearing microscopic pedicellariæ; on plates adjacent to lateral spine the actinal adambulacral spines much shorter than on the others; near base of ray the larger actinal spine shorter and stouter, and gradually flaring at the tip, which is broad, truncate, and flower-like, as in *Brisinga cricophora.*

Actinostome rather wide, 16 mm. in diameter; mouth plates small, inconspicuous, rather narrow, with a flaring inner or free margin, the combined pair being shield-shaped; armature consisting of 3 or 4 membrane-invested, pedicellaria-bearing spinelets on the inner free flange-like margin of the plate, that nearest median suture the shortest, the rest evenly graduated in size outward; at aboral end of plate 1 or 2 similar spinelets reaching nearly across furrow; on actinal surface 2 much larger and heavier, pointed, sacculate spinules standing in a longitudinal linear series, the inner the longer, and slightly nearer the median suture; occasionally 3 spinules.

Madreporic body small, subtubercular, situated near margin of raised portion of disk, its borders beset with numerous spinelets.

Color in life: Abactinal surface of disk flame scarlet; rays "salmon pink" with a yellowish cast, much lighter than disk; edges of furrow pinker; spines "salmon color;" tube feet pinkish orange.

Locality: Station 4530, Monterey Bay, 958 fms., soft mud.

This species is particularly characterized by the very extensive genital region, which extends about half the length of ray, and by the exceedingly delicate abactinal plates.

# PARASITES OF FISHES OF BEAUFORT, NORTH CAROLINA.

By EDWIN LINTON, Ph. D.,
*Professor of Biology, Washington and Jefferson College.*

# CONTENTS.

Page.
Introduction ... 323
Additions to helminthology of North America ... 325
List of the author's papers on parasites of marine fishes of North America ... 328
List of entozoa with references to literature ... 328
Lists of parasites and their hosts ... 330
  Acanthocephala ... 330
  Nematoda ... 330
  Cestoda ... 331
  Trematoda ... 333
  Protozoa ... 335
  Copepoda parasitica ... 336
Analytical key to genera of cestodes ... 336
Table of new distomes and of some undetermined species recorded as Distomum ... 338
List of fifty-nine Beaufort fishes, with notes on their food and parasites ... 339
Index ... 417
Explanation of plates ... 419
Plates I to XXXIV ... 428

# PARASITES OF FISHES OF BEAUFORT, NORTH CAROLINA.

By EDWIN LINTON, PH. D.,
*Professor of Biology, Washington and Jefferson College.*

## INTRODUCTION.

The following report is based mainly on notes and sketches which were made at the time of collecting at the laboratory of the Bureau of Fisheries, Beaufort, N. C., in the months of July and August, 1901 and 1902. While it has not been possible to subject the whole collection to detailed study, in most cases, especially wherever the character of the material permitted, the information obtained at the time of collecting has been supplemented by subsequent study of the preserved material. Most of the species of distomes, for example, were studied with the aid of specimens which had been stained and mounted in balsam. In a few special cases serial sections were cut in order to clear up some anatomical obscurity.

This report should, perhaps, be understood as a contribution to economic rather than to systematic zoology. It is hoped that it may be followed by more detailed descriptions and more precise determinations than are here essayed.

Since the plan of the report has as its central idea an enumeration of all the parasitic forms which were actually found, brief descriptions are made necessary. In the carrying out of this plan no doubt some forms are mentioned which, even though accompanied with figures, it may not be possible to bring into harmony with subsequent finds. Frequently, after the most painstaking search in a large number of fish, a single distome, for example, would be found in the resulting collection of entozoa which differed specifically and, according to the later classification, generically, from any other find of this or of previous years. Such distome, moreover, even with careful manipulation, may show but a part of the anatomy necessary to a satisfactory determination. To bestow new specific names under such conditions is not to be thought of. On the other hand, if no mention be made of examples of entozoa unless found in sufficient numbers or in such excellent condition as to permit full descriptions, little will be accomplished toward an enumeration of the species which infest our fishes.

To the naturalist no defense need be made for time and energy spent in the study of life in any of its phenomena. To those who are not naturalists, however, some justification is due. Particularly does this become proper when the general public, by means of such laboratories as those of the Bureau of Fisheries, furnishes facilities for scientific inquiry. One who has never undertaken to get knowledge at first-hand from nature is likely to have little conception of the vast amount of work which is oftentimes necessary for the establishment of a very simple proposition. Suppose, for example, exact and complete information is desired as to the food of the English sparrow. It should not require much reflection to convince anyone that before an adequate answer can be made to such an inquiry trustworthy observations must be made by competent investigators on the feeding habits of this bird, both adult and young, in different localities throughout the year and through a series of years. But the general public may wish to know, and in this case has a right to know, what advantage there is to it in such scientific inquiry as is implied by an investigation made on the food and the parasites of fishes.

It may, I think, be confessed that, so far as may be seen while the investigations are in progress, much of the information which is collected will be of interest only to zoologists. In view, however, of the well-known fact that many diseased conditions and even epidemics result from the presence of parasites, and, further, that the parasites are as a rule introduced, either as eggs or larvæ, along with the food, it is not difficult to see that the more complete and systematic our knowledge becomes of the interrelations of the animals which harbor the parasite—interrelations which depend very intimately on the food habits of fishes—the more certain are we to be able to cope successfully with any disease which may arise. A case in point is furnished by one of the recent triumphs of medical knowledge. It is scarcely possible that the cause of malaria and of yellow fever could have been discovered if it had not been for the previous contributions to knowledge made by investigators in parasitism. The germ of malaria is a parasite whose round of life is passed in the blood cells of man and in certain organs of the mosquito. The germ of yellow fever seems to have a similar history. These interrelations between the mosquito and man were not even dreamed of a generation ago. The history of trichinosis is now so well known that a simple allusion to it in this connection is sufficient. Every well-informed person knows, or may easily know, how the disease is communicated and what part is played in the matter by the pig and by rats and mice.

The immense value to humanity of such a discovery as the cause of malaria and of yellow fever is entirely beyond our powers to estimate; and yet this value must not be credited to this one discovery alone, as if it were a thing apart. No less credit must be given to the long line of investigators whose persistent interrogations of nature have led up to this discovery, and will surely lead to others no less valuable.

In the summer of 1901 the material for study upon which this paper is based was obtained in large part from the fish market, and therefore came from fish of adult size. The following year a good deal of seining was done by the laboratory party. Almost every day, in fact, during the latter half of the season, the seine was dragged in the harbor and adjacent waters. This placed at my disposal not only several species of fishes which had not been examined the preceding year, but, as a rule, much smaller individuals of the common food fishes of the region than those which are taken to the markets. The number of fish examined in 1901 was 842; in 1902 the number was 1,209. As a rule only the viscera and body cavity were examined for entozoa, although occasionally search was made in the muscles for parasites encysted in the flesh, and the character of the food was always noted.

The authority for the names of fishes in this report is Jordan and Evermann's Fishes of North and Middle America.

The faithful and efficient work of Mr. C. W. Stone, who assisted me in the collection of material, is most gratefully acknowledged.

## ADDITIONS TO THE HELMINTHOLOGY OF NORTH AMERICA.

### ACANTHOCEPHALA.

The adult form of *Echinorhynchus sagittifer* Linton is here recorded for the first time. This name was assigned to certain immature forms which have been found on the viscera of several of our food fishes. The adult was found at Beaufort in the intestine of the cobia (*Rachycentron canadus*).

At Woods Hole, Mass., the most abundant species of *Echinorhynchus* is the one which I have referred to the species *E. acus*, which infests a large number of the fishes of that region. It was not found at Beaufort, while *E. pristis*, not common at Woods Hole, was found frequently and in some 14 different hosts.

### NEMATODA.

One new nematode is recorded—*Filaria galeata* sp. nov., from the bonnet-head shark (*Sphyrna tiburo*),

The generic name *Heterakis* is used instead of *Cucullanus* for certain small worms which I have recorded under the latter name in my Parasites of the Fishes of the Woods Hole Region. In like manner the same generic name is used for some small nematodes which I recorded in the above-cited paper as *Ascaris* (?) *sp.*

There is much need of systematic work on those nematodes which are referred by different authors to the genera *Cucullanus*, *Dacnitis*, and *Heterakis*.

Immature nematodes, most, if not all, belonging to the genus *Ascaris*, were found in 33 of the 59 species of fishes examined. So far as these have been studied the most frequently recurring type is charcterized by having a diverticulum of the bulbous base of the œsophagus which extends caudad and lies parallel to the intestine. There is also a short diverticulum of the intestine which extends cephalad beside the œsophagus (figs. 26–29, 33). Another type has only the intestinal diverticulum. In it the basal bulb of the œsophagus is elongated instead of being nearly globular as in the others, while the postanal region is usually transversely corrugated (figs. 31, 32).

### CESTODA.

Three new cestodes are recorded: *Dibothrium tortum*, *Otobothrium insigne*, *Rhynchobothrium plicatum*. The first, from *Synodus fœtens*, should perhaps be referred to a new genus, between *Monobothrium* and *Dibothrium* (*Bothriocephalus*). The second is from *Carcharhinus obscurus*, and the third from *Sphyrna tiburo*.

One of the most interesting finds recorded in this paper is the species of *Rhinebothrium*, near *R. flexile* Linton, found encysted on the viscera of the toad-fish (*Opsanus tau*). These cysts, occurring as they usually do in clusters (fig. 59), suggest some habit of budding while in the blastocyst (plerocercus) stage. Nothing of this kind, however, was demonstrated. Since this species appears to be very common in the toad-fish of Beaufort, and toad-fish are abundant and easy to get, the form might well repay a more extended study than is given it in this report. The same species was found encysted in six hosts, including the toad-fish.

*Rhynchobothrium speciosum* Linton was found for the first time in the adult stage. The final host was *Carcharhinus obscurus*. Among the larval forms belonging to the genus *Rhynchobothrium*, one species was of very frequent occurrence, having been found in 15 different fishes. Doubtless some of the finds, in which the proboscides were not seen extended, also belong to this species, which is usually characterized in these notes as being small, with relatively long hooks, suggesting, indeed, *R. longispine* Linton (figs. 87–93).

*Otobothrium crenacolle* Linton, recorded in my Woods Hole papers as adult only, in *Sphyrna zygæna*, was found encysted in 14 different Beaufort fishes. It is quite evident that this form is encysted in the fishes of Woods Hole also. *Rhynchobothrium* sp., from *Rhombus triacanthus* (Parasites of Fishes of the Woods Hole Region, pp. 453–454, figs. 255–265) is really *Otobothrium crenacolle*.

Identification of the Tetrarhynchidæ is difficult unless the proboscides can be seen. It is better, indeed, that the proboscides be completely everted, since differences in the size and arrangement of the hooks in some species are often very considerable in different parts of the proboscis. But little can be determined relative to the arrangement of the hooks on the inverted proboscis.

At least two species of the genus *Synbothrium* are represented: *S. filicolle* Linton, neck of scolex elongated, slender; hooks, at least those at the base of the proboscis, slender and spine-like. *Synbothrium* sp., scolex relatively stout; hooks of several different sizes and forms, but all more or less recurved. (Figs. 116–118.)

The latter appears to be near the larval form referred in a former paper to *Tetrarhynchus erinaceus* Beneden (Proceedings U. S. National Museum, vol. XIX, 1898, pp. 811–812, pl. LXVII, figs. 1–8), which belongs in the genus *Synbothrium*.

The larval cestodes, doubtless representing several different genera, recorded in Parasites of the Woods Hole Region under the name *Scolex polymorphus*, were found in 34 of the 59 Beaufort fishes examined (figs. 76–79).

As at Woods Hole, these forms are found not only in the alimentary tracts of their hosts, but also in the cystic ducts of several. They are almost never absent from the cystic duct of *Cynoscion regalis*. In all cases where these worms have been obtained from the cystic duct and from the intestine of the same fish, those coming from the cystic duct are larger, plumper, and more opaque than those from the intestine. Some of the older larvæ suggested the genera *Calliobothrium*, *Acanthobothrium*, and *Phoreiobothrium*.

One interesting cyst may be adverted to here (fig. 115) as furnishing an example of the absorption of an encysted larva. The cyst contains two bunches of hooks, which represent all that is left of a larval cestode, probably *Tetrarhynchus bisulcatus*.

## TREMATODA.

It has been thought best to retain the generic name *Distomum* (see Bulletin of the U. S. Fish Commission for 1899, p. 408). Respecting the classification of the distomes, the author is aware that his papers should be brought into some sort of harmony with the nomenclature of Loos, Lühe, Pratt, Stiles, and others. An attempt indeed was made to refer some of the new forms to genera into which the old genus *Distomum* has been broken up, but the result was not altogether satisfactory, in that it seemed to necessitate the creation of still other new genera, which, in view of the small number of specimens in many cases, and their poor condition, or immaturity in others, seemed to me to be an undesirable thing to do.

The following new specific names are proposed:

*Aspidogaster ringens* from *Micropogon undulatus* and *Trachinotus carolinus.*
*Distomum aduncum* from *Opsanus tau.*
*Distomum corpulentum* from *Lagodon rhomboides* and *Orthopristis chrysopterus.*
*Distomum imparispine* from *Rachycentron canadus.*
*Distomum inconstans* from *Chætodipterus faber.*
*Distomum pectinatum* from *Bairdiella chrysura* and *Trachinotus carolinus.*
*Gasterostomum baculum* from *Scomberomorus maculatus.*
*Gasterostomum gorgon* from *Seriola lalandi.*

Other distomes were found which are evidently new, but to which it is not desirable to give names until more material is available. The form shown in fig. 204 is a case in point. In the find represented by that figure there was but one specimen, and it was necessary to cut it into sections before the anatomy could be made out.

The appendiculate distomes referred to the species *D. monticellii* were found in 19 species of fish. In many cases they were immature, so that identification was not always certain. The ratio between oral and ventral sucker was not uniform. In some the diameter of the ventral sucker was less than twice that of the oral; in others it was more than three times as great. In the case of the specimens from *Menticirrhus americanus* it is likely that more than one species is recorded under *D. monticellii.* The adult worms referred to this species agree fairly well with the one from *Rachycentron canadus* (fig. 154). The most characteristic feature is the lobed vitelline glands.

I think that there is much reason to believe that the same species of distome is affected differently by different specific hosts in which it becomes adult.

The forms which were referred to the genus *Aspidogaster* were particularly difficult to classify. Their position in this genus must be regarded as provisional, and points to the probable necessity of either extending the limits of the genus *Aspidogaster*, or of establishing a new genus.

A *Gasterostomum*, found in 8 species of fishes, has been referred to the species *G. gracilescens* Rudolphi.

The abundance of representatives of this genus is especially interesting and suggestive in view of the relative abundance of the larval *Gasterostomum* (*Bucephalus haimeanus* Lacaze-Duthiers) in the oyster.

In all cases the number of trematodes and of adult cestodes, nematodes and acanthocephala given on any date represents all that were seen. This is not the case, however, with many of the encysted forms. In a few cases the number recorded simply indicates the number of cysts collected by my assistant. As a matter of fact, such forms as the encysted larvæ of *Otobothrium crenacolle* and *Tetrarhynchus bisulcatus* as a rule occur in relatively large numbers.

The plan followed in this paper, of arranging the parasites by number under the several hosts, will, it is believed, make it possible to refer to any form with almost as much precision as if specific names had been given less sparingly. In order to simplify the work of printing this report a list has been prepared of all the species mentioned in it which have been described in my former papers, with references to the literature. References to the appended list of papers only are given, since in them will be found citations to other and older literature.

## PAPERS REFERRED TO BY NUMBER IN THE FOLLOWING LIST OF ENTOZOA.

**1.** Notes on Entozoa of Marine Fishes of New England. Report U. S. Fish Commission for 1886.
**2.** Notes on Entozoa of Marine Fishes of New England. Part II, Cestodes. Report U. S. Fish Commission for 1887.
**3.** Notes on Entozoa of Marine Fishes of New England. Part III, Acanthocephala. Report U. S. Fish Commission for 1888.
**4.** Notes on Larval Cestode Parasites of Fishes. Proceedings U. S. National Museum. Vol. XIX. 1897.
**5.** Notes on Cestode Parasites of Fishes. Proceedings U. S. National Museum. Vol. XX. 1897.
**6.** Notes on Trematode Parasites of Fishes. Proceedings U. S. National Museum. Vol. XX. 1897.
**7.** Fish Parasites collected at Woods Hole in 1898. Bulletin U. S. Fish Commission for 1899. (1900.)
**8.** Parasites of Fishes of the Woods Hole Region. Bulletin U. S. Fish Commission for 1899. (1901.)

## LIST OF ENTOZOA MENTIONED IN THIS REPORT, WITH REFERENCES TO ORIGINAL DESCRIPTIONS AND MORE IMPORTANT DESCRIPTIVE NOTES PUBLISHED IN THE AUTHOR'S EARLIER PAPERS.

[Figures in **heavy-faced** type refer to the preceding list of papers.]

NOTE.—Many of the references to **8** are to alphabetic lists, where detailed references will be found. Only species which are mentioned in the author's previous papers are included in this list.

*Acanthobothrium paulum* Linton. **2**, pp. 816–819, pl. VIII, figs. 1–7. **7**, p. 275. **8**, p. 411.
*Anthobothrium laciniatum* Linton. **2**, pp. 754–759, pl. III, figs. 10–13; pl IV, figs. 1–3. **5**, p. 439. **8**, p. 411.
*Anthobothrium pulvinatum* Linton. **2**, pp. 759–765, pl. IV, figs. 4–9; pl. V, figs. 1–2. **5**, pp. 439–440, pl. XXX, fig. 1. **7**, p. 275. **8**, p. 411.
*Anthocephalum gracile* Linton. **2**, pp. 794–796, pl. VII, figs. 1–2. **7**, p. 275. **8**, p. 411.
*Ascaris brevicapitata* Linton. **8**, p. 425, pl. III, figs. 19–22.
*Ascaris habena* Linton. **7**, pp. 282, 302–303, pl. XLIII, figs. 109–115. **8**, p. 468.
*Ascaris increscens* Molin. **8**, p. 452, pl. VIII, figs. 62–64, and pp. 487–488.
*Ascaris inquies* Linton. **8**, p. 452, pl. VI, figs. 46–50.
*Ascaris incurva* Rudolphi. **8**, pp. 410, 446–448, 481; pl. IV, figs. 29–32.
*Ascaris neglecta* Leidy. **8**, p. 465, pl. V, figs. 33–36.
*Crossobothrium angustum* Linton (*Orygmatobothrium angustum*). **1**, pp. 468–469, pl. III, figs. 1–3. **2**, pp. 796–799, pl. VII, fig. 3. **5**, p. 443. **7**, p. 272. **8**, pp. 426, 427.
*Distomum appendiculatum* Rudolphi. **7**, p. 289, pl. XXXVI, figs. 25, 26. **8**, p. 415, etc., pl. XXVIII, figs. 312–314; in eighteen hosts.
*Distomum areolatum* Rudolphi. **7**, pp. 279, 293–294, pl. XXXIX, figs. 60–63. **8**, p. 415, etc.
*Distomum bothryophoron* Olsson. **8**, pp. 437, 439, pl. XXXII, figs. 355, 356.
*Distomum dentatum* Linton. **7**, pp. 283, 294, pl. XXXIX, figs. 64–67. **8**, p. 483.
*Distomum globiporum* Rudolphi. **8**, p. 486, pl. XXXI, fig. 347.
*Distomum grandiporum* Rudolphi. **6**, pp. 520–521, pl. XLIV, fig. 9. **8**, p. 486.
*Distomum hispidum* Abilgaard. **8**, p. 478, pl. XXIX, figs. 321–323.
*Distomum monticellii* Linton. **6**, pp. 518–520, pl. XLIV, figs. 2–8. **8**, pp. 451, 473, 482.
*Distomum nigroflavum* Rudolphi. **6**, pp. 530–531, pl. XLVIII, figs. 8–11, and pl. XLIX, figs. 1, 2. **7**, p. 282. **8**, p. 466.
*Distomum polyorchis* Stossich. **8**, p. 460–461, pl. XXXIII, figs. 363–365.
*Distomum pudens* Linton. **7**, pp. 283, 290–291, pl. XXXVII, figs. 40–47.
*Distomum pyriforme* Linton. **7**, pp. 279, 292–293, pl. XXXVIII, figs. 52–59. **8**, p. 415, etc.
*Distomum simplex* Rudolphi. **6**, pp. 525–526, pl. XLVIII, figs. 3–7. **8**, p. 415, etc., pl. XXX, figs. 331, 332.
*Distomum tenue* Linton. **6**, pp. 535–536, pl. LII, figs. 2–8. **8**, pp. 455, 468.
*Distomum tornatum* Rudolphi. **6**, pp. 513–514, pl. XLII, figs. 6–12. **8**, pp. 442, 444, 452, 455, 469, pl. XXVIII, fig. 310.

*Distomum valde-inflatum* Stossich. **6**, pp. 527–528, pl. xlvii, figs. 10–14 and pl. xlviii, figs. 1, 2. **8**, pp. 444, 464.

*Distomum vibex* Linton. **7**, pp. 281, 291–292, pl. xxxviii, figs. 48–51. **8**, p. 464.

*Distomum vitellosum* Linton. **7**, p. 290, pl. xxxvii, figs. 38, 39. **8**, p. 416, etc., pl. xxx, figs. 333–340; in eighteen hosts.

*Echinorhynchus pristis* Rudolphi. **3**, pp. 530–532, pl. lvi, figs. 31–41, pl. lvii, figs. 42–53. **8**, p. 409, etc., figs. 12–14.

*Echinorhynchus proteus* Westrumb. **1**, pp. 496–497, pl. vi, figs. 3–5. **3**, pp. 537–538, pl. lx, figs. 85–88. **8**, p. 409.

*Echinorhynchus sagittifer* Linton. **1**, pp. 493–496, pl. vi, figs. 1, 2. **3**, pp. 535–536, pl. lix, fig. 80. **8**, p. 409, etc.

*Gasterostomum arcuatum* Linton. **7**, pp. 297–298, pl. lxi, figs. 85–90. **8**, pp. 427, 446.

*Gasterostomum baculum* sp. nov. **8** (*Gasterostomum* sp.), p. 447, pl. xxxiv, figs. 369–372.

*Heterakis foveolata* Rudolphi. **8** (*Cucullanus globosus*, and sp.), pp. 476, 488, pl. xvii, figs. 205, 206.

*Heterakis* sp. **8** (*Ascaris* (?) sp.), p. 481, pl. vii, figs. 57–61, (*Cucullanus* sp.), p. 441, pl. xvii, figs. 207, 208.

*Ichthyonema globiceps* Rudolphi. **8**, pp. 437, 446, 450, 457, pl. xviii, figs, 209–217.

*Lecanicephalum peltatum* Linton. **2**, pp. 802–805, pl. ix, figs. 2–4. **7**, p. 275. **8**, p. 433.

*Lecanocephalus annulatus* Molin. **8**, p. 455, pl. xix, figs. 220–223.

*Monostomum vinal-edwardsii* Linton. **8**, p. 470, pl. xxxiv, figs. 373–376.

*Onchobothrium uncinatum* Diesing. **5**, p. 446, pl. xxxiv, figs. 2–5. **8**, p. 433.

*Otobothrium crenacolle* Linton. **2**, pp. 850–853, pl. xiii, figs. 9–15, pl. xiv, figs. 1–4. **7**, p. 273. **8**, p. 428.

*Otobothrium dipsacum* Linton. **4**, pp. 806–807, pl. lxvi, figs. 1–5.

*Paratænia medusia* Linton. **2**, pp. 862–866, pl. xv, figs. 5–9. **5**, p. 440. **7**, p. 275. **8**, p. 433.

*Phoreiobothrium lasium* Linton. **1**, pp. 474–476, pl. iv, figs. 24–29. **2**, pp. 819–820. **5**, p. 447. **7**, pp. 272–273. **8**, pp. 426, 427, 428.

*Phoreiobothrium triloculatum* Linton. **8**, p. 427, pl. xxvi, fig. 292.

*Phyllobothrium foliatum* Linton. **2**, pp. 787–794, pl. vi, figs. 5–10. **5**, p. 443. **7**, p. 275. **8**, p. 433.

*Rhinebothrium flexile* Linton. **2**, pp. 768–771, pl. v, figs. 3–5. **7**, p. 275. **8**, p. 433.

*Rhynchobothrium bulbifer* Linton. **1** (*R. tenuicolle* Rudolphi), pp. 486–488, 7 pl. v, figs. 17, 18. **2**, pp. 825–829, pl. x, figs. 8, 9, pl. xi, figs. 1, 2. **4**, p. 793. **5**, p. 448. **8**, 412, etc.; noted in seven hosts.

*Rhynchobothrium hispidum* Linton. **2**, pp. 833–835, pl. ix, figs. 12–17. **7**, p. 275. **8**, p. 433.

*Rhynchobothrium longispine* Linton. **2**, pp. 835–837, pl. xi, figs. 18–20.

*Rhynchobothrium speciosum* Linton. **4**, pp. 801–805, pl. lxiv, figs. 13, 14, pl. lxv, figs. 1–7. **7**, p. 784. **8**, p. 413, etc.; noted in eleven hosts.

*Rhynchobothrium tenuispine* Linton. **2**, pp. 837–838, pl. xii, figs. 1, 2. **5**, pp. 448–449, pl. xxxiv, fig. 8. **8**, 426, 433.

*Rhynchobothrium tumidulum* Linton. **2**, pp. 829–832, pl. xi, figs. 3–11. **8**, p. 468.

*Scolex polymorphus* Rudolphi. **1** (larval *Tetrabothria*), pp. 3–4, pl. vi, figs. 8, 9. **4** (larval *Echeneibothria*), pp. 789–792, pl. i, figs. 4–15. **7**, noted under name of "larval cestodes," as occurring in a number of hosts, pp. 270–284. **8**, p. 413, etc.; noted in twenty-eight hosts.

*Spongiobothrium variabile* Linton. **1**, pp. 462–464, pl. ii, figs. 13–16. **2**, pp. 778–780. **5**, p. 442. **7**, p. 275. **8**, p. 433.

*Synbothrium filicolle* Linton. **2** (*Syndesmobothrium filicolle*), pp. 861–862, pl. xv, figs. 2–4. **4**, p. 819, pl. lxviii, fig. 10. **7**, p. 275. **8**, pp. 413–414, etc.; noted in ten hosts.

*Tetrarhynchus bicolor* Bartels. **4**, pp. 813–815, pl. lxviii, figs. 1–6. **7**, p. 271. **8**, p. 414, etc.; noted in six hosts.

*Tetrarhynchus bisulcatus* Linton. **1** (*Rhynchobothrium bisulcatum*), pp. 479–486, pl. iv, figs. 9–23. **2**, pp. 857–861, pl. xiv, figs. 10–12, pl. xv, fig. 1. **4**, pp. 810–811, pl. lxvi, figs. 11–15. **5**, p. 452. **7**, p. 272. **8**, p. 414, etc.; noted in twelve hosts.

*Tetrarhynchus erinaceus* Beneden. **4**, pp. 811–812, pl. lxvii, figs. 1–8. **8**, pp. 451, 454, 460.

*Tetrarhynchus robustus* Linton. **2**, pp. 855–857, pl. xiv, figs. 7–9. **8**, p. 414, etc.; noted in five hosts.

## LIST OF PARASITES AND THEIR HOSTS.

### ACANTHOCEPHALA.

| Parasite. | Host. | Page. |
|---|---|---|
| Echinorhynchus pristis Rudolphi | Bairdiella chrysura | 387 |
| | Cynoscion regalis | 384 |
| | Dasyatis say | 346 |
| | Fundulus majalis | 355 |
| | Lagodon rhomboides | 380 |
| | Leiostomus xanthurus | 392 |
| | Lophopsetta maculata | 414 |
| | Menticirrhus americanus | 398 |
| | Micropogon undulatus | 394 |
| | Monacanthus hispidus | 401 |
| | Orthopristis chrysopterus | 377 |
| | Paralichthys albiguttus | 411 |
| | Pomatomus saltatrix | 368 |
| | Symphurus plagiusa | 416 |
| Echinorhynchus proteus Westrumb | Synodus fœtens | 353 |
| Echinorhynchus sagittifer Linton (adult) | Rachycentron canadus | 371 |
| Echinorhynchus sagittifer Linton (young) | Coryphæna hippurus | 372 |
| | Cynoscion regalis | 384 |
| | Lagodon rhomboides | 381 |
| | Micropogon undulatus | 394 |
| | Orthopristis chrysopterus | 377 |
| | Paralichthys albiguttus | 411 |
| | Paralichthys dentatus | 410 |
| | Prionotus tribulus | 404 |
| | Synodus fœtens | 353 |
| Echinorhynchus sp. (fragments) | Cynoscion regalis | 384 |
| | Paralichthys albiguttus | 411 |

### NEMATODA.

| Parasite. | Host. | Page. |
|---|---|---|
| Ascaris brevicapitata Linton | Carcharhinus obscurus | 339 |
| Ascaris habena Linton | Carcharhinus obscurus | 339 |
| | Leiostomus xanthurus | 392 |
| | Opsanus tau | 406 |
| | Scoliodon terræ-novæ | 342 |
| Ascaris increscens Molin | Coryphæna hippurus | 372 |
| Ascaris incurva Rudolphi | Seriola lalandi | 364 |
| Ascaris inquies Linton | Rachycentron canadus | 371 |
| Ascaris neglecta Leidy | Chilomycterus schœpfi | 403 |
| Ascaris sp | Kyphosus sectatrix | 383 |
| Ascaris sp | Coryphæna hippurus | 372 |
| Ascaris sp | Micropogon undulatus | 395 |
| Filaria galeata sp. nov | Coryphæna equisetis | 374 |
| | Sphyrna tiburo | 344 |
| Heterakis foveolata Rudolphi | Anguilla chrisypa | 351 |
| | Galeichthys milberti | 350 |
| | Leptocephalus conger | 351 |
| | Micropogon undulatus | 395 |
| Heterakis sp | Leiostomus xanthurus | 392 |
| | Lophopsetta maculata | 414 |
| | Paralichthys albiguttus | 412 |
| | Sciænops ocellatus | 390 |
| Ichthyonema globiceps Rudolphi | Paralichtnys albiguttus | 412 |
| | Pomatomus saltatrix | 368 |
| Ichthyonema sp | Coryphæna hippurus | 372 |
| Immature nematodes (*Ascaris*), usually encysted on viscera.<br>Type with a diverticulum from the base of the œsophagus and another from the anterior end of the intestine (figs. 26–30). | Bairdiella chrysura | 387 |
| | Brevoortia tyrannus | 352 |
| | Centropristes striatus | 375 |
| | Cynoscion nebulosus | 385 |
| | Cynoscion regalis | 384 |
| | Fundulus majalis | 355 |
| | Hyporhamphus roberti | 358 |
| | Leiostomus xanthurus | 392 |
| | Lophopsetta maculata | 414 |
| | Menidia menidia | 360 |
| | Menticirrhus americanus | 398 |
| | Micropogon undulatus | 395 |
| | Opsanus tau | 407 |
| | Orthopristis chrysopterus | 377 |
| | Paralichthys albiguttus | 412 |
| | Paralichthys dentatus | 411 |
| | Pomatomus saltatrix | 368 |
| | Prionotus scitulus | 401 |
| | Prionotus tribulus | 404 |
| | Scoliodon terræ-novæ | 342 |
| | Spheroides maculatus | 402 |
| | Stolephorus brownii | 353 |
| | Synodus fœtens | 354 |
| | Trachinotus carolinus | 366 |
| | Tylosurus raphidoma | [illegible] |

*List of parasites and their hosts*—Continued.

NEMATODA—Continued.

| Parasite. | Host. | Page. |
|---|---|---|
| Immature nematodes (*Ascaris*), usually encysted on viscera.<br>Type with basal bulb of œsophagus elongate and without diverticulum, intestine with diverticulum at anterior end, post-anal region transversely corrugated (figs. 31, 32). | Bairdiella chrysura | 387 |
| | Caranx hippos | 365 |
| | Carcharhinus milberti | 341 |
| | Centropristes striatus | 375 |
| | Coryphæna hippurus | 372 |
| | Lagodon rhomboides | 381 |
| | Paralichthys albiguttus | 412 |
| | Paralichthys dentatus | 411 |
| | Pomatomus saltatrix | 368 |
| | Scoliodon terræ-novæ | 342 |
| | Scomberomorus regalis | 363 |
| | Tylosurus marinus | 356 |
| Immature nematodes (*Ascaris*)<br>Type with clavate œsophagus. | Centropristes striatus | 375 |
| | Micropogon undulatus | 395 |
| Immature nematodes (minute) | Galeichthys milberti | 360 |
| | Pomatomus saltatrix | 368 |
| | Pteroplatea maclura | 349 |
| Lecanocephalus annulatus Molin | Diplodus holbrookii | 383 |
| Nematode (fragment) | Menticirrhus americanus | 398 |
| Nematodes (small, probably two species) | Eucinostomus gula | 387 |
| | Leiostomus xanthurus | 392 |
| | Tylosurus marinus | 356 |

CESTODA.

| Parasite. | Host. | Page. |
|---|---|---|
| Acanthobothrium paulum Linton | Dasyatis say | 348 |
| | Pteroplatea maclura | 349 |
| | Raja lævis | 346 |
| Anthobothrium laciniatum Linton | Carcharhinus obscurus | 339 |
| | Scoliodon terræ-novæ | 343 |
| Anthobothrium pulvinatum Linton | Dasyatis say | 346 |
| Anthocephalum gracile Linton | Dasyatis say | 347 |
| Calliobothrium sp | Scoliodon terræ-novæ | 342 |
| Cestode cysts and larvæ | Bairdiella chrysura | 387 |
| | Lagodon rhomboides | 385 |
| | Leiostomus xanthurus | 393 |
| | Leptocephalus conger | 351 |
| | Lophopsetta maculata | 415 |
| | Paralichthys albiguttus | 412 |
| | Pomatomus saltatrix | 369 |
| | Rachycentron canadus | 371 |
| | Scomberomorus regalis | 363 |
| Crossobothrium angustum Linton | Carcharhinus obscurus | 339 |
| | Scoliodon terræ-novæ | 343 |
| Dibothrium, larvæ | Anguilla chrisypa | 351 |
| | Centropristes striatus | 375 |
| | Hyporhamphus roberti | 358 |
| | Lophopsetta maculata | 415 |
| | Paralichthys albiguttus | 412 |
| | Pomatomus saltatrix | 369 |
| Dibothrium tortum sp. nov | Synodus fœtens | 354 |
| Echeneibothrium sp | Dasyatis say | 346 |
| Lecanicephalum peltatum Linton | Dasyatis say | 347 |
| Onchobothrium uncinatum Diesing | Dasyatis say | 347 |
| Otobothrium crenacolle Linton, encysted | Bairdiella chrysura | 388 |
| | Carcharhinus obscurus | 340 |
| | Coryphæna hippurus | 372 |
| | Cynoscion nebulosus | 386 |
| | Cynoscion regalis | 384 |
| | Galeichthys milberti | 360 |
| | Lagodon rhomboides | 381 |
| | Micropogon undulatus | 394 |
| | Opsanus tau | 409 |
| | Orthopristis chrysopterus | 377 |
| | Paralichthys albiguttus | 413 |
| | Pomatomus saltatrix | 369 |
| | Scomberomorus regalis | 363 |
| Otobothrium crenacolle Linton (adult) | Scoliodon terræ-novæ | 344 |
| Otobothrium dipsacum Linton | Centropristes striatus | 375 |
| Otobothrium insigne sp. nov | Carcharhinus obscurus | 340 |
| Otobothrium sp., encysted | Tylosurus raphidoma | 357 |
| Paratænia medusia Linton | Dasyatis say | 347 |
| Phoreiobothrium lasium Linton | Carcharhinus obscurus | 340 |
| | Scoliodon terræ-novæ | 343 |
| Phoreiobothrium triloculatum Linton | Carcharhinus obscurus | 340 |
| | Scoliodon terræ-novæ | 343 |
| Phyllobothrium foliatum Linton | Carcharhinus obscurus | 340 |
| | Dasyatis say | 347 |

*List of parasites and their hosts*—Continued.

CESTODA—Continued.

| Parasite. | Host. | Page. |
|---|---|---|
| Rhinebothrium flexile Linton | Dasyatis say | 347 |
| | Scoliodon terræ-novæ | 342 |
| Rhinebothrium sp., encysted. Near R. flexile | Cynoscion regalis | 384 |
| | Dasyatis centrura | 347 |
| | Micropogon undulatus | 395 |
| | Opsanus tau | 407 |
| | Rachycentron canadus | 371 |
| | Siphostoma fuscum | 359 |
| Rhynchobothrium hispidum Linton | Dasyatis say | 318 |
| | Sphyrna tiburo | 345 |
| Rhynchobothrium plicatum sp. nov | Scoliodon terræ-novæ | 343 |
| | Sphyrna tiburo | 345 |
| Rhynchobothrium sp. (fig. 131) | Dasyatis say | 348 |
| Rhynchobothrium sp. (figs. 129–130*c*) | Scoliodon terræ-novæ | 343 |
| Rhynchobothrium speciosum Linton (adult) | Carcharhinus obscurus | 340 |
| Rhynchobothrium speciosum Linton (encysted) | Coryphæna hippurus | 373 |
| | Cynoscion regalis | 384 |
| | Pomatomus saltatrix | 369 |
| Rhynchobothrium teniuspine Linton (adult) | Dasyatis say | 348 |
| Rhynchobothrium teniuspine Linton (encysted) | Micropogon undulatus | 395 |
| Rhynchobothrium tumidulum Linton (adult) | Dasyatis say | 348 |
| Rhynchobothrium tumidulum Linton (encysted) | Opsanus tau | 409 |
| Rhynchobothrium sp. (encysted)<br>Cysts usually small, oval, often clustered in mesentery and on viscera.<br>Larvæ rather short, but with comparatively long contractile bulbs and hooks, suggesting R. longispine (figs. 87–94). | Anguilla chrisypa | 351 |
| | Bairdiella chrysura | 388 |
| | Centropristes striatus | 375 |
| | Lagodon rhomboides | 381 |
| | Leiostomus xanthurus | 393 |
| | Micropogon undulatus | 395 |
| | Orthopristes chrysopterus | 377 |
| | Paralichthys albiguttus | 412 |
| | Paralichthys dentatus | 411 |
| | Prionotus scitulus | 404 |
| | Prionotus tribulus | 405 |
| | Pteroplatea maclura | 349 |
| | Rachycentron canadus | 371 |
| | Synodus fœtens | 354 |
| | Trachinotus carolinus | 366 |
| Rhynchobothrium sp. (encysted)<br>Cysts usually small, elliptical, or fusiform on viscera.<br>Larvæ with long necks and proboscides, oval or pyriform bulbs and minute hooks, suggesting some form like R. tenuispine. | Bairdiella chrysura | 388 |
| | Centropristes striatus | 375 |
| | Cynoscion regalis | 384 |
| | Orthopristes chrysopterus | 377 |
| Rhynchobothrium sp. (encysted)<br>Cysts usually small, various shapes on viscera.<br>Larvæ with long necks and proboscides, small, but not minute hooks, suggesting form like R. plicatum (figs. 97, 98). | Bairdiella chrysura | 388 |
| | Centropristes striatus | 375 |
| | Cynoscion nebulosus | 386 |
| | Menticirrhus americanus | 398 |
| | Micropogon undulatus | 395 |
| | Orthopristis chrysopterus | 377 |
| | Pomatomus saltatrix | 369 |
| Rhynchobothrium sp. (encysted)<br>Cysts on viscera.<br>Larvæ with broad, emarginate bothria, some at least having elevated borders (figs 99, 100). | Elops saurus | 352 |
| | Galeichthys milberti | 350 |
| | Scomberomorus maculatus | 362 |
| | Scomberomorus regalis | 363 |
| Rhynchobothrium sp. (larva) | Menticirrhus americanus | 399 |
| Scolex polymorphus Rudolphi | Anguilla chrisypa | 351 |
| | Bairdiella chrysura | 387 |
| | Centropristes striatus | 375 |
| | Coryphæna equisetis | 374 |
| | Cynoscion nebulosus | 385 |
| | Cynoscion regalis | 384 |
| | Diplodus holbrookii | 383 |
| | Etropus crossotus | 415 |
| | Fundulus heteroclitus | 356 |
| | Galeichthys milberti | 350 |
| | Hyporhamphus roberti | 358 |
| | Lagodon rhomboides | 381 |
| | Leiostomus xanthurus | 393 |
| | Leptocephalus conger | 351 |
| | Lophopsetta maculata | 415 |
| | Menidia menidia | 360 |
| | Menticirrhus americanus | 398 |
| | Micropogon undulatus | 395 |

*List of parasites and their hosts*—Continued.

CESTODA—Continued.

| Parasite. | Host. | Page. |
|---|---|---|
| Scolex polymorphus Rudolphi | Monacanthus hispidus | 401 |
| | Opsanus tau | 407 |
| | Orthopristis chrysopterus | 377 |
| | Paralichthys albiguttus | 412 |
| | Prionotus tribulus | 405 |
| | Pomatomus saltatrix | 369 |
| | Pteroplatea maclura | 349 |
| | Rachycentron canadus | 371 |
| | Sciænops ocellatus | 390 |
| | Scoliodon terræ-novæ | 342 |
| | Siphostoma fuscum | 359 |
| | Stolephorus brownii | 353 |
| | Symphurus plagiusa | 416 |
| | Synodus fœtens | 354 |
| | Trachinotus carolinus | 366 |
| | Tylosurus marinus | 356 |
| Spongiobothrium variabile Linton | Dasyatis say | 347 |
| Synbothrium filicolle Linton | Carcharhinus milberti | 341 |
| Synbothrium filicolle Linton (encysted) | Carcharhinus obscurus | 341 |
| | Lophopsetta maculata | 415 |
| | Micropogon undulatus | 396 |
| | Paralichthys albiguttus | 413 |
| | Pomatomus saltatrix | 369 |
| | Pteroplatea maclura | 349 |
| | Scoliodon terræ-novæ | 341 |
| | Scomberomorus maculatus | 362 |
| | Scomberomorus regalis | 363 |
| | Cynoscion regalis | 385 |
| Synbothrium sp.<br>Type with strong, recurved hooks. | Galeichthys milberti | 350 |
| | Orthopristis chrysopterus | 377 |
| | Pomatomus saltatrix | 369 |
| Tænia sp. (encysted) | Fundulus majalis | 359 |
| Tetrarhynchus bicolor Bartels | Coryphæna hippurus | 373 |
| Tetrarhynchus bisulcatus Linton (adult) | Carcharhinus milberti | 371 |
| | Carcharhinus obscurus | 340 |
| | Scoliodon terræ-novæ | 341 |
| Tetrarhynchus bisulcatus Linton (encysted)<br>Usually in submucosa of alimentary canal, especially in the stomach. | Bairdiella chrysura | 388 |
| | Caranx hippos | 365 |
| | Cynoscion nebulosus | 386 |
| | Cynoscion regalis | 385 |
| | Lagodon rhomboides | 381 |
| | Leiostomus xanthurus | 393 |
| | Lophopsetta maculata | 415 |
| | Menticirrhus americanus | 399 |
| | Micropogon undulatus | 395 |
| | Opsanus tau | 409 |
| | Orthopristis chrysopterus | 377 |
| | Paralichthys albiguttus | 413 |
| | Pomatomus saltatrix | 369 |
| | Prionotus scitulus | 404 |
| | Prionotus tribulus | 405 |
| | Rachycentron canadus | 371 |
| | Scomberomorus regalis | 363 |
| | Scomberomorus maculatus | 362 |
| | Silene vomer | 366 |
| | Siphostoma fuscum | 359 |
| | Spheroides maculatus | 402 |
| | Symphurus plagiusa | 416 |
| Tetrarhynchus robustus Linton | Carcharhinus obscurus | 341 |

TREMATODA.

| | | |
|---|---|---|
| Aspidogaster ringens sp. nov | Micropogon undulatus | 397 |
| | Trachinotus carolinus | 367 |
| Cercariæ | Monacanthus hispidus | 401 |
| Dactylocotyle sp | Brevoortia tyrannus | 352 |
| Diclidophora sp | Orthopristis chrysopterus | 380 |
| Distomum aduncum sp. nov | Opsanus tau | 409 |
| Distomum appendiculatum Rudolphi | Brevoortia tyrannis | 352 |
| | Caranx hippos | 365 |
| | Coryphæna equisetis | 374 |
| | Lagodon rhomboides | 382 |
| | Leiostomus xanthurus | 393 |
| | Lophopsetta maculata | 415 |
| | Orthopristis chrysopterus | 378 |
| | Prionotus scitulus | 404 |
| | Prionotus tribulus | 405 |

*List of parasites and their hosts*—Continued.

TREMATODA—Continued.

| Parasite. | Host. | Page. |
|---|---|---|
| Distomum areolatum Rudolphi | Bairdiella chrysura | 389 |
| | Micropogon undulatus | 396 |
| | Orthopristis chrysopterus | 379 |
| | Sciænops ocellatus | 391 |
| Distomum bothryophoron Olsson | Micropogon undulatus | 397 |
| | Orthopristis chrysopterus | 378 |
| | Paralichthys dentatus | 411 |
| Distomum corpulentum sp. nov | Lagodon rhomboides | 382 |
| | Orthopristis chrysopterus | 378 |
| Distomum dentatum Linton | Coryphæna equisetis | 374 |
| | Lophopsetta maculata | 415 |
| | Micropogon undulatus | 396 |
| | Paralichthys albiguttus | 413 |
| | Paralichthys dentatus | 411 |
| | Pomatomus saltatrix | 369 |
| | Rachycentron canadus | 372 |
| Distomum globiporum Rudolphi | Fundulus majalis | 356 |
| | Leiostomus xanthurus | 395 |
| | Orthopristis chrysopterus | 378 |
| Distomum grandiporum Rudolphi | Leptocephalus conger | 351 |
| Distomum hispidum Abilgaard | Menticirrhus americanus | 400 |
| | Seriola lalandi | 364 |
| Distomum imparispine sp. nov | Rachycentron canadus | 371 |
| Distomum inconstans sp. nov | Chætodipterus faber | 400 |
| Distomum monticellii Linton<br>Many of these distomes being immature the specific identification, in such cases, is uncertain. | Bairdiella chrysura | 388 |
| | Centropristes striatus | 376 |
| | Coryphæna equisetis | 374 |
| | Coryphæna hippurus | 373 |
| | Cynoscion nebulosus | 386 |
| | Lagodon rhomboides | 381 |
| | Leiostomus xanthurus | 393 |
| | Menidia menidia | 360 |
| | Menticirrhus americanus | 399 |
| | Micropogon undulatus | 396 |
| | Paralichthys albiguttus | 413 |
| | Paralichthys dentatus | 411 |
| | Pomatomus saltatrix | 369 |
| | Prionotus tribulus | 405 |
| | Rachycentron canadus | 371 |
| | Scomberomorus regalis | 363 |
| | Seriola lalandi | 364 |
| | Synodus fœtens | 354 |
| Distomum nigroflavum Rudolphi | Trachinotus carolinus | 366 |
| | Coryphæna equisetis | 374 |
| Distomum pectinatum, sp. nov | Bairdiella chrysura | 389 |
| | Trachinotus carolinus | 366 |
| Distomum polyorchis Stossich | Cynoscion regalis | 385 |
| Distomum pudens Linton | Paralichthys albiguttus | 413 |
| | Rachycentron canadus | 372 |
| Distomum pyriforme Linton | Brevoortia tyrannus | 372 |
| | Lagodon rhomboides | 382 |
| | Menidia menidia | 360 |
| Distomum simplex Rudolphi | Micropogon undulatus | 397 |
| Distomum tenue Linton | Caranx hippos | 365 |
| | Centropristes striatus | 376 |
| | Coryphæna equisetis | 374 |
| | Coryphæna hippurus | 373 |
| | Cynoscion nebulosus | 386 |
| | Menticirrhus americanus | 399 |
| | Micropogon undulatus | 396 |
| | Orthopristis chrysopterus | 379 |
| | Pomatomus saltatrix | 370 |
| | Sciænops ocellatus | 391 |
| Distomum tornatum Rudolphi | Coryphæna equisetis | 374 |
| | Coryphæna hippurus | 372 |
| | Menticirrhus americanus | 398 |
| | Synodus fœtens | 355 |
| | Tylosurus marinus | 356 |
| Distomum valde-inflatum Stossich | Cynoscion nebulosus | 386 |
| | Leiostomus xanthurus | 393 |
| | Menticirrhus americanus | 400 |
| | Micropogon undulatus | 396 |
| | Monacanthus hispidus | 401 |
| | Opsanus tau | 409 |
| | Orthopristis chrysopterus | 379 |
| | Paralichthys albiguttus | 414 |
| | Rachycentron canadus | 372 |
| | Siphostoma fuscum | 359 |
| | Trachinotus carolinus | 366 |
| Distomum vibex Linton | Spheroides maculatus | 402 |

*List of parasites and their hosts*—Continued.

TREMATODA—Continued.

| Parasite. | Host. | Page. |
|---|---|---|
| Distomum vitellosum Linton | Bairdiella chrysura | 388 |
| | Cynoscion regalis | 385 |
| | Dasyatis centrura | 348 |
| | Lagodon rhomboides | 382 |
| | Leiostomus xanthurus | 393 |
| | Leptocephalus conger | 351 |
| | Menticirrhus americanus | 399 |
| | Micropogon undulatus | 397 |
| | Monacanthus hispidus | 401 |
| | Opsanus tau | 409 |
| | Orthopristis chrysopterus | 378 |
| | Paralichthys albiguttus | 413 |
| | Pomatomus saltatrix | 369 |
| | Prionotus scitulus | 404 |
| | Prionotus tribulus | 405 |
| | Sciænops ocellatus | 390 |
| | Trachinotus carolinus | 366 |
| | Tylosurus marinus | 357 |
| Distomum sp<br>List of unidentified specimens comprising distomes, usually represented by one or very few examples, and they often immature or in a poor state of preservation. | Bairdiella chrysura (figs. 168, 169) | 389 |
| | Chilomycterus schœpfi (fig. 208) | 403 |
| | Coryphæna esquisetis (figs. 213, 214) | 374 |
| | Coryphæna hippurus | 373 |
| | Cynoscion regalis (Proceedings U. S. N. M. XX, p. 537) | 385 |
| | Siphostoma fuscum | 359 |
| | Spheroides maculatus | 402 |
| | Galeichthys milberti (fig. 209) | 350 |
| | Lagodon rhomboides (fig. 179) | 382 |
| | Leiostomus xanthurus (figs. 173, 198, 199) | 393 |
| | Lophopsetta maculata (figs. 171, 172) | 415 |
| | Paralichthys albiguttus | 413 |
| | Rachycentron canadus | 372 |
| | Menidia menidia (Bul. U. S. F. C. for 1899, p. 444; figs. 357, 358) | 360 |
| | Micropogon undulatus | 397 |
| | Opsanus tau | 410 |
| | Opsanus tau (fig. 215) | 410 |
| | Opsanus tau (figs. 167, 205) | 410 |
| | Paralichthys albiguttus | 414 |
| | Prionotus scitulus | 404 |
| | Pteroplatea maclura | 349 |
| | Seriola lalandi | 364 |
| | Sphyræna borealis | 361 |
| | Stolephorus brownii | 353 |
| | Symphurus plagiusa | 416 |
| | Trachinotus carolinus | 366 |
| Gasterostomum arcuatum Linton | Caranx hippos | 365 |
| | Scomberomorus regalis | 363 |
| Gasterostomum baculum sp. nov | Scomberomorus maculatus | 362 |
| Gasterostomum gorgon sp. nov | Seriola lalandi | 364 |
| Gasterostomum gracilescens Rudolphi | Caranx hippos | 365 |
| | Menidia menidia | 360 |
| | Opsanus tau | 410 |
| | Paralichthys albiguttus | 414 |
| | Pomatomus saltatrix | 370 |
| | Spheroides maculatus | 402 |
| | Stolephorus brownii | 353 |
| | Tylosurus marinus | 357 |
| Gasterostomum sp | Orthopristis chrysopterus | 379 |
| Gasterostomum sp | Seriola lalandi | 364 |
| Microcotyle sp | Cynoscion regalis | 385 |
| | Pomatomus saltatrix | 370 |
| Monostomum vinal-edwardsii Linton | Opsanus tau | 410 |
| | Orthopristis chrysopterus | 379 |
| Monostomum sp<br>List of unidentified specimens comprising monostomes usually represented by but one or by a very few examples and they often in a poor state of preservation. | Fundulus majalis | 356 |
| | Menidia menidia | 360 |
| | Orthopristis chrysopterus | 379 |
| | Trachinotus carolinus | 367 |
| | Orthopristis chrysopterus | 379 |

PROTOZOA.

| | | |
|---|---|---|
| Gregarines | Siphostoma fuscum | 359 |
| Myxobolus (Henneguya) sp | Archosargus probatocephalus | 382 |
| | Sciænops ocellatus | 390 |
| | Trachinotus carolinus | 366 |

The copepod parasites mentioned in this report have been turned over to Prof. C. B. Wilson, who has kindly given me the generic names of a number of them.

*List of parasites and their hosts*—Continued.

COPEPODA PARASITICA.

| Parasite. | Host. | Page. |
|---|---|---|
| Species of Anchorella | Micropogon undulatus | 398 |
| | Mugil cephalus | 361 |
| Argulus sp | Diplodus holbrookii | 383 |
| Bomolochus sp | Orthopristis chrysopterus | 380 |
| Brachiella sp | Brevoortia tyrannus | 352 |
| Species of Caligus | Bairdiella chrysura | 389 |
| | Coryphæna equisetis | 374 |
| Chondracanthus sp | Chilomycterus schœpfi | 403 |
| Copepod parasites | Seriola lalandi | 364 |
| | Tylosurus caribbæus | 358 |
| | Tylosurus marinus | 357 |
| Species of Ergasilus | Menidia menidia | 360 |
| | Mugil cephalus | 361 |
| | Orthopristis chrysopterus | 380 |
| Species of Lernæonema | Coryphæna equisetis | 374 |
| | Upeneus maculatus | 362 |
| Species of Lernanthropus | Bairdiella chrysura | 389 |
| | Paralichthys dentatus | 411 |
| | Pomatomus saltatrix | 370 |
| | Prionotus tribulus | 405 |
| | Tylosurus marinus | 357 |
| Pandarus sp | Carcharhinus obscurus | 341 |

## ANALYTICAL KEY TO GENERA OF CESTODES MENTIONED IN THIS REPORT AND IN THE PAPERS GIVEN IN THE LIST ON PAGE 328.

1. Scolex spherical or subspherical, with cup-like bothria ... 3
2. Scolex of various shapes, but unlike 1 ... 4
3. {Scolex simple, either with or without rostellum ... *Tænia*
   {Scolex with retractile, tentacle-like appendages in front ... *Paratænia*
4. {Scolex disk-shape without bothria ... *Discocephalum*
   {Scolex provided with bothria ... 5
5. {Bothria two[a] ... *Dibothrium (Bothriocephalus)*
   {Bothria four ... 6
6. {Bothria immersed in a discoidal or subglobular mass ... 7
   {Bothria distinct ... 8
7. {Scolex discoidal ... *Lecanicephalum*
   {Scolex subglobular with subglobular myzorhynchus ... *Tylocephalum*
8. {Scolex unarmed ... 9
   {Scolex armed ... 19
9. {Bothria without auxiliary suckers ... 10
   {Bothria with auxiliary suckers ... 13
10. {Bothria with costæ ... 11
    {Bothria without costæ ... 12
11. {Scolex with myzorhynchus ... *Echeneibothrium*
    {Scolex without distinct myzorhynchus in adult ... *Rhinebothrium*
12. {Bothria in pairs with frilled or lobed borders ... *Spongiobothrium*
    {Bothria cruciform with entire margins ... *Anthobothrium*
13. {Two auxiliary suckers on each bothrium ... *Orygmatobothrium*
    {One auxiliary sucker to each bothrium ... 14
14. {Auxiliary suckers relatively large, formed from anterior part of bothrium ... 15
    {Auxiliary suckers small, circular ... 16
15. {Auxiliary suckers entire, scolex with terminal haustellum ... *Monorygma*
    {Auxiliary suckers horseshoe shape, anterior ends of bothria partly retractile ... *Calyptrobothrium*
16. {Bothria in pairs ... 17
    {Bothria cruciform ... 18
17. {Scolex with terminal muscular disk ... *Cestode from Tile-fish*
    {Scolex without terminal muscular disk ... *Phyllobothrium*
18. {Bothria slender, pedicelled, with crenulate borders ... *Anthocephalum*
    {Bothria short-pedicelled, border not crenulate ... *Crossobothrium*
19. {Bothria armed with hooks ... 20
    {Scolex provided with retractile spiny proboscides ... 25

---

[a] The worms referred provisionally to this genus in this report appear to be without bothria. See *D. tortum* under *Synodus*.

| | | |
|---|---|---|
| 20. | Hooks inconspicuous, of densely fibrous structure | *Thysanocephalum* |
| | Hooks chitinous, structureless | 21 |
| 21. | Hooks simple | 22 |
| | Hooks compound | 23 |
| 22. | Bothria without auxiliary suckers | *Onchobothrium* |
| | Bothria with auxiliary suckers anterior to hooks | *Calliobothrium* |
| 23. | Scolex flattened, bothria in pairs, hooks in pairs united by a chitinous bar | *Platybothrium* |
| | Bothria cruciform | 24 |
| 24. | Hooks with two prongs each, bothria costate | *Acanthobothrium* |
| | Hooks with three prongs each, bothria loculate at posterior end | *Phoreiobothrium* |
| 25. | Bothria two | 26 |
| | Bothria four | 27 |
| 26. | Bothria without auxiliary pits | *Rhynchobothrium* |
| | Bothria with auxiliary pits | *Otobothrium* |
| 27. | Bothria lateral | *Tetrarhynchus* |
| | Bothria terminal | *Synbothrium* |

## TABLE OF NEW DISTOMES AND OF SOME UNDETERMINED SPECIES RECORDED AS DISTOMUM SP. IN THIS PAPER.

| Species. | Suckers. | Vitellaria. | Testes. | Ovary. | Size (millimeters). | Ova (microns). | Intestine. | Remarks. |
|---|---|---|---|---|---|---|---|---|
| D. corpulentum sp. nov. from Lagodon rhomboides (figs. 180–182). | Ventral as much as four times oral. | Coarse granular, posterior and lateral to ventral sucker | Two, transverse, a short distance behind ventral sucker. | Transverse, between ventral sucker and testes. | 2.25 | Not uniform, 51 x 27, 41 x 24, 27 x 20, 30 x 15. | Diverticula at anterior end; forks not traced to posterior end. | Body subspherical; œsophagus very short. |
| D. imparispine sp. nov. from Rachycentron canadus (figs. 189–194). | Ventral a little larger than oral. | Posterior and lateral granular masses, abundant, but not reaching ventral sucker. | Two, on median line, near together and near posterior end. | Oval-elliptical, near testes and in front of them. | 9 | 70 x 40 | Forks simple | Thirty-four oral spines, unequal; anterior part of body with small spines; cirrus pouch behind ventral sucker; pharynx elongated. |
| D. aduncum sp. nov. from Opsanus tau (figs. 195–197). | Ventral smaller than oral. | A few subglobular or lobed masses, lateral toward posterior end of body. | Two, lateral, in front of vitellaria. | Globular, in front of left testis. | 0.87 | Variable, average of best formed, 20 x 10. | Forks simple, reaching but short distance back of ventral sucker. | Minutely spinose; genital aperture a sucker to left of ventral sucker; pharynx remote from mouth; œsophagus long |
| D. pectinatum sp. nov. from Bairdiella chrysura (figs. 200–203). | Ventral twice oral. | Granular masses, lateral, not abundant. | Two, near posterior end. | Oval, in front of testes, remote. | 2.1 | 22 x 15, 18 x 17. | Forks simple, reaching to posterior end. | Fleshy papillæ on head and neck; pharynx cylindrical. |
| D. inconstans sp. nov. from Chætodipterus faber (figs. 183–187). | About equal | Abundant, posterior and lateral, may extend to pharynx. | Six on left, four on right side, a little behind middle of body. | Lobed, between lateral groups of testes. | 0.7 to 2.1; very variable in shape. | 60 x 40, some variation. | Forks simple, to posterior end; œsophagus distinct. | Cirrus bulb shifting with state of contraction. Minute, rounded spines on anterior half of body. |
| D. sp. from Symphurus plagiusa (figs. 161–164). | Oral equal to or slightly larger than ventral. | Lateral masses, probably dendritic. | Two, lateral | In front of right testis toward median line. | 0.78 to 1.05 | 22 x 15 | Forks simple, extending to near posterior end | Body covered with minute, flat spines. Some of the specimens obliquely truncate posteriorly. |
| D. sp. from Rachycentron canadus (figs. 171, 172). | Ventral twice oral. | Lobed behind ovary. | Two, close together, near middle of body. | Subspherical, close behind testes. | 1 | 40 x 20 | | Ova much smaller at one end than the other; i. e., oval-pointed. |
| D. sp. from Trachinotus carolinus (fig. 204). | Ventral about twice oral. | Peripheral, from ventral sucker to near anterior end, not abundant. | Two, close together, near posterior end. | Lobed, at extreme posterior end behind testes. | 5.5 | 27 x 14 | Forks simple, extending to posterior end; œsophagus none. | Ventral sucker near posterior end. Genital aperture close behind forks of intestine. |
| D. sp. from Bairdiella chrysura (figs. 168–170). | Ventral larger than oral. | Coarse granular masses, posterior and lateral to pharynx, abundant | Two, diagonal toward posterior. | Oval, close to testes, in front of them, to right. | 0.84 | 63 x 35 | Forks simple, to posterior end. | Pharynx pyriform, larger than ventral sucker. |
| D. sp. from Lagodon rhomboides (fig. 179). | Ventral sucker smaller than oral. | Abundant granular masses, posterior and lateral to pharynx. | Two, somewhat lobed under pressure toward posterior end. | Oval, transverse in front of testes. | 2 | 75 x 58 | | |

## LIST OF FIFTY-NINE SPECIES OF BEAUFORT FISHES WITH NOTES ON FOOD AND ON THE PARASITES FOUND IN THEM IN JULY AND AUGUST 1901 AND 1902.

### Carcharhinus obscurus, *Dusky Shark.*

| Date. | Number and size of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| July 8 | 1 (length 4½ feet) | Alimentary canal empty. |
| 1902. | | |
| July 11 | 1 (length 5 feet) | Fish. |
| July 26 | 1 (length 6 feet) | Fish (sheepshead, used for bait). |
| July 29 | 1 (length 6 feet 7½ inches, weight 111 pounds.) | Alimentary canal empty. |
| August 26 | 1 (length 7½ feet, weight 203 pounds.) | Fish. |

These sharks are referred to this species although they do not agree in all diagnostic features with the descriptions published in Jordan & Gilbert's Fishes of North America, or Jordan & Evermann's later work. The pectorals do not reach quite to the first dorsal. The second dorsal is larger than the anal. There is not much difference between the upper and lower teeth. They agree rather well with *Prionace* in the character of the fins, but the nose is much shorter and broader than in that genus.

The specimen examined on July 26 had been caught less than an hour before by Mr. Russell J. Coles. It was a much cleaner cut and more graceful shark than any other seen by me at Beaufort. The tips of the pectorals were black, a character not noted in the others. The specimen taken on July 29 was caught at the Fish Commission wharf and was seen by me while it was still alive. Mr. Coles stated that the tips of all the fins of his specimen were black when it was first captured. He also said that it was much more voracious and gamy than the others he had taken.

#### NEMATODES.

1. *Ascaris habena* Linton.

1902.—July 26, 1 female. This specimen was not in good condition and looked as if it had been introduced recently with the food, but was not in the proper final host; length 45 mm.

2. *Ascaris brevicapitata* Linton. [Figs. 22, 23.]

1902.—Aug. 26, 8, immature. Five of these were taken directly from the stomach; the others were found in washings from the stomach and intestine. One of the smaller forms was transparent enough to allow it to be demonstrated that it belonged to the type which has a diverticulum of the intestine and an elongated basal enlargement of the œsophagus. This character in the encapsuled and immature forms found in various teleosts is associated with a corrugated postanal region, which, however, was not the case with these worms. They were found with their heads penetrating the mucus membrane of their host, where they caused some irritation, as was evidenced by the inflamed condition of the mucus membrane where they were attached.

The shortest measured 10 mm. in length, the longest 20. Some were slender, others were plump. There was considerable variation in the shape of the posterior end, but all agreed in having rather thickish lips at the anal aperture.

The jaws, while not fully developed, are seen to be those of a very short-jawed species. The specimens are referred provisionally to the species *A. brevicapitata*, which was originally described from the tiger shark.

#### CESTODES.

3. *Anthobothrium laciniatum* Linton.

1901.—July 8, few.

1902.—July 26, 2. July 29, 3. Aug. 26, numerous. All found in the intestine.

4. *Crossobothrium angustum* Linton.

1901.—July 8, very numerous.

1902.—July 11, few and small. July 26, 2. July 29, 36. Aug. 26, very numerous. All from intestine.

5. *Phyllobothrium foliatum* Linton.

1902.—July 11, few, small. July 29, 2, length 45 mm. Aug. 26, 2 small specimens and 1 larger, referred doubtfully to this species. Auxiliary acetabula were seen on the bothria, but the arrangement of the latter was more like that of *Crossobothrium* than *Phyllobothrium*.

6. *Phoreiobothrium lasium* Linton.

1901.—July 8, 2.

1902.—July 11, few, small. Aug. 26, few.

7. *Phoreiobothrium triloculatum* Linton.

1902.—July 29, 30, 1 measuring 55 mm. in length, others probably longer. Aug. 26, not numerous.

8. *Rhynchobothrium speciosum* Linton.

This specific name was made to accommodate certain encysted forms, which were found in several species of teleosts.

Owing to the lateness of the hour on two occasions and the abundance of other material to look over on all occasions when specimens of this species were found, but few notes were made of the fresh material. Enough was determined, however, to warrant the conclusion that the species is certainly either *R. speciosum* or very near it.

1902.—July 11, 2. One of these after killing in Lang's picro-aceto corrosive fluid measured 150 mm. in length. July 26, 4, found in both intestine and stomach. July 29, 2; 1 of these, measuring 60 mm. in length, presented an interesting abnormality, in what appeared to be the beginning of supernumerary contractile bulbs situated 8.5 mm. behind the normal bulbs. Length of head and neck to base of normal bulbs 7.5 mm. The second specimen measured 25 mm. in length. Aug. 20, few.

9. *Otobothrium crenacolle* Linton.

1902.—July 11, several in small cysts of elliptical outline in the submucosa of the stomach wall. July 26, immense numbers encysted in stomach wall, cysts small, ellipsoidal and oval-elliptical. Length of oval blastocyst, 1.5; greatest diameter, 0.9; length of larva 0.45 mm. Aug. 26, few.

10. *Otobothrium insigne* sp. nov. [Figs. 141–145.]

Head broad, bothria lateral, widely divergent at the posterior end, with flexible borders; neck elongated, expanding at posterior end into a prominent funnel-form collar, which overlaps the anterior end of the body; accessory bothrial organs conspicuous; proboscides armed with hooks of diverse shapes and sizes; contractile bulbs oval, about two and a half times as long as broad.

Body, so far as developed, of nearly uniform breadth; first segments beginning a short distance back of neck and very short; ripe segments not seen, last segment one and one-half times as long as broad; reproductive organs seen only in rudimentary condition; reproductive apertures irregularly alternate at a point a little in front of the middle of the lateral margin of the segment.

Lateral vessels conspicuous, slightly sinuous.

Dimensions, in millimeters, of specimen mounted in balsam: Length 10; length of head and neck 4.2; length of head 0.7; breadth of head 1.2, of neck just back of head 0.4, of neck at base 1.2, of body just back of neck 0.87; contractile bulbs, length 0.72, breadth 0.28; length of proboscis, estimated, 3; diameter, excluding hooks, 0.09; diameter, including hooks, 0.15; length of longest hook 0.045; diameter of accessory bothrial organ 0.15; distance from base of neck to first segment 0.6; length of first segment 0.05, breadth 0.82; last segment, immature, length 0.9, breadth 0.6.

Rudiments of reproductive organs begin 0.5 back of the junction between neck and body; collar of neck overlaps body 0.3. The distinction between the neck and body in the stained specimen is sharp.

1902.—July 26, 2.

11. *Tetrarhynchus bisulcatus* Linton.

Numerous in pylorus and intestine. The heads of these worms, as is usual with this species, were found to be embedded in the mucous membrane, sometimes several heads together in the same pit. This condition is attended with much irritation and gives rise to some inflammation in the mucous membrane.

1901.—July 8.

1902.—July 11, numerous. July 26, few. July 29, 1, associated with *T. robustus*. Aug. 26, very numerous in stomach, where they were attached to the mucous membrane.

12. *Tetrarhynchus robustus* Linton.

1902.—July 26, 10, in stomach and intestine. The heads were much larger than those of *T. bisulcatus*, the collars looser, with uneven or somewhat broken posterior borders. July 29, 3.

13. *Synbothrium filicolle* Linton.

1902.—July 11, few; July 26, several, from cysts in stomach wall, a few possibly free in the stomach. Several dark-colored cysts were cut out of the stomach wall, but owing to the lateness of the hour were not examined until the next day. No larvæ were noted at the time of collecting. The material was left in sea water over night. When the cysts were examined in the morning several specimens of *Synbothrium* were found associated with the cysts, from which they had evidently emerged. When the alcoholic material was reexamined a few days later a dark-colored cyst was found to contain degenerate waxy tissue with probicides of *S. filicolle*.

It would appear that some of these parasites had penetrated the mucous membrane of their host as larva with blastocyst attached and there became encysted.

14. *Cysts*.

1902.—July 11, 2 in mesentery. These cysts were translucent, the larger 9 by 11 mm., the other somewhat smaller. The larger cyst was opened, but nothing was found in the lymph with which it was filled but a small blood clot.

PARASITIC COPEPODS.

15. *Pandarus* sp.

1902.—July 29, 5, dark-brown.

### **Carcharhinus milberti**, *Blue Shark*.

1902.—July 25, 1. The identification of this shark was made with the aid of Jordan & Gilbert's Fishes of North America. While not agreeing with the description of this species in all particulars it was in closer agreement with it than with any other described by the above-named authors.

The shark was caught by Mr. Russell J. Coles of Danville, Va., with rod and reel. It was a female with young, exceptionally thick-bodied, and over 9 feet in length. Alimentary canal empty, except for a few small fragments (crystalline lenses, etc.) of fish, a plate from the test of a sea urchin and a few thin strips of vegetable tissue.

NEMATODES.

1. *Immature nematodes* (*Ascaris*).

1902.—July 25, 10. This is the type with elongated bulbular basal portion of œsophagus and corrugated post-anal region. The parasites had evidently been recently introduced with the food.

CESTODES.

2. *Tetrarhynchus bisulcatus* Linton.

1902.—July 25, 12 scolices with fragments of strobiles.

3. *Synbothrium filicolle* Linton.

1902.—July 25, 1 scolex; posterior end behind contractile bulbs somewhat macerated. One mature segment, 7 mm. long, and 2 broad, with dark-brown ova.

**Scoliodon terræ-novæ**, *Sharp-nosed Shark.*

| Date | Number of fish examined. | Food notes. (Except where otherwise specified all the sharks were about a foot in length.) |
|---|---|---|
| 1901. | | |
| July 6 | 6 | Fragments of fish and sand. |
| July 8 | 6 | Fragments of fish and shrimp. |
| July 9 | 1 | Fragments of fish. |
| July 10 | 1 | Food completely digested except a piece of sea lettuce. |
| July 18 | 3 | Crabs. |
| July 20 | 3 | Fish and crustacea. |
| July 22 | 1 (length 3½ feet) | Stomach empty, intestine with yellow mucus and sand. |
| Do | 8 | Crabs. |
| July 24 | 1 (length 3½ feet; female with young.) | Stomach filled with fish (menhaden); large amount of mud in stomach and intestine. |
| Do | 3 | Fish and annelids. |
| July 25 | 10 | Fish. Large numbers of a four-celled organism. These were of nearly uniform size, varying but little from 0.2 mm. in length and 0.02 mm. in breadth. |
| July 26 | 6 | Fragments of fish, crustacea, and annelids. |
| July 27 | 1 | Alimentary canal empty. |
| August 5 | 5 | Fish. |
| August 6 | 1 | Shrimp and other crustaceans. |
| August 7 | 3 (1 about 2 feet) | Fish. |
| August 9 | 2 | Crustacea (hermit, crabs, etc.); one caught with fiddler crab for bait. |
| August 12 | 3 | Fish and shrimp. |
| August 15 | 4 | Do. |
| August 16 | 1 | Fish. |
| Do | 3 | Toadfish and shrimp. |
| 1902 | | |
| July 11 | 3 (3 feet in length) | Fish in one; stomachs of others empty. |
| July 16 | 1 (14 inches) | Fish in stomach, shrimp in intestine. |
| July 18 | do | Alimentary canal empty. |
| July 23 | do | Fish, shrimp. |
| July 29 | do | Fish. |
| August 14 | do | Fragments of small fish. |

### NEMATODES.

1. *Immature nematodes* (*Ascaris*).

Type with diverticulum of intestine at anterior end and slender posterior diverticulum of œsophagus. These, together with Nos. 2 and 3, are doubtless introduced with the food and withstand the digestive action rather better than the tissues in which they are lodged, but do not become mature in the shark.

1901.—July 22, July 24, Aug. 10, few.

1902.—July 29, few.

2. *Immature nematodes* (*Ascaris*).

Type represented by forms with short diverticulum of intestine and corrugated postanal region.

1901.—Aug. 15, Aug. 16, few. These had evidently been introduced recently with the food.

3. *Ascaris habena* Linton (?).

1901.—Aug. 15, fragment of a male, head missing, intestine red-brown. Two pairs of postanal papillæ and 17 pairs of preanal papillæ were made out. Parasite evidently introduced with food.

### CESTODES.

4. *Scolex polymorphus* Rudolphi.

1901.—Aug. 5, 1. Aug. 7, few.

1902.—Aug. 14, several, with red pigment in neck and 2 costæ developed on bothria.

5. *Calliobothrium* (?) sp., young. [Fig. 80.]

1901.—Aug. 16, 1, a scolex with rudiments of hooks. This immature scolex appears to be a more advanced stage of *Scolex polymorphus* than I have yet found.

6. *Rhinebothrium flexile* (?) Linton.

1901.—July 22, larvæ, from intestine, some not yet everted, others completely everted and active. When the scolex is in motion the bothria may be extended until they are filiform, particularly at their anterior ends. July 26, 1, scolex with blastocyst attached; a good view of the bothria was obtained; the number of loculi on each appears to be about 32. Aug. 16, 1, scolex. This was probably introduced with the toadfish, fragments of which were found in the intestine.

7. *Anthobothrium laciniatum* Linton. [Fig. 126.]

1901.—July 8, 1, small (4.5 mm. in length), from spiral valve. A free segment with the anterior end prolonged into a short, slender neck, surmounted by a round knob, which functioned as a sucker, measured 1.68 mm. in length and 0.7 mm. in breadth. July 9, numerous, length about 9 mm.; neck and anterior segments densely covered with exceedingly minute spines; ripe segments rather numerous, free, active, the largest measuring, when fully extended, 6 mm. in length and 2 mm. in breadth, the central portion being filled with ova, which are about 0.02 mm. in diameter. July 18, 2. July 20, 2. July 22, several. July 24, 2. July 24, few. July 25, 6. July 26, few. July 27, few. Aug. 5, 2. Aug. 6, 5. Aug. 7, several. Aug. 10, several. Aug. 15, few. Aug. 16, few.

1902.—July 11, 15, maximum length, 15 mm. July 23, few. Aug. 14, numerous, with large numbers of free segments.

8. *Crossobothrium angustum* Linton. (*Orgymatobothrium angustum* Linton.)

1901.—July 22, rather numerous; small, some not yet begun to form segments. July 24, 1. July 24, few, small. July 25, 6. July 27, few, small. Aug. 5, 2. Aug. 7, few. Aug. 15, few. Aug. 16, 2.

1902.—Found on July 11, 18, 23, and Aug. 14; maximum number found in one host, 30. Dimensions of 1 in millimeters: Length 7.5; diameter of bothrium 0.15; of neck 0.07 to 0.22; distance to first segment 2; last segment, length 1.17; breadth 0.48.

9. *Phoreiobothrium lasium* Linton.

1901.—July 6, 2, with several free segments. July 8, 1, and free segments. July 18, 1, and free segments. July 20, 1. July 25, 12, and free segments. Aug. 5, 3. Aug. 16, 1.

1902.—July 11, 1.

10. *Phoreiobothrium triloculatum* Linton.

1901.—July 24, 24. Most of these specimens were about 40 mm. in length. There were also numerous free segments with eggs. These segments soon became dark colored in sea water and discharged the eggs on the bottom of the glass vessel in which they were lying.

1902.—July 11, 2; length 25 mm. July 16, 1 scolex, no segments yet developed; length 2 mm.; hooks small. The specimen looks very much like some of the more advanced specimens of *Scolex polymorphus* which have occasionally been found, save that the bothria have assumed the characteristics of *P. loculatum*.

11. *Rhynchobothrium* sp. [Figs. 129–130c.]

1902.—July 11, 1. The following notes were made on the living worm: Bothria relatively large, with thin, flexible borders, which in certain states of contraction appear to be somewhat frilled. While lying in sea water the edges of the bothria were in continual motion, expanding and contracting, and so producing a constant wave-like motion. Head and neck white, body yellowish white. Head approximately two and a half times as broad as the neck at the widest part. Neck widest next to the head, tapering to its posterior end, where it is still wider than the anterior segments. The body displayed a tendency to coil into a spiral, which made its study in life difficult. It was straightened out in the killing fluid, when it measured 30 mm. in length, with enough fragments to bring the total length up to 45 mm. Proboscides partly everted, showing hooks of various sizes. In the killing fluid the head and neck shortened somewhat and remained much thicker than the body.

The bothria in the alcoholic specimen are nearly circular, about 1.12 mm. in diameter; contractile bulbs 0.9 in length and 0.3 in diameter; proboscides 0.15 in diameter excluding and 0.21 including hooks; large hooks 0.096 in length, small hooks 0.021; the large hooks are on the median, the small hooks mainly on the lateral side of the proboscis.

12. *Rhynchobothrium plicatum* sp. nov.

See No. 2 under *Sphyrna tiburo*.

1901.—July 22, several; scolices still attached to blastocysts, but completely everted and very active; a red pigment patch in neck at anterior end of contractile bulbs. July 24, 2, with scolices; attached to blastocysts; other blastocysts in the lot from which the scolices were lost in the collecting. The length of the part to which the scolex was attached was, after killing, 8 mm. My notes made at the time of collecting place this species near *R. tenuispine*. July 25, 10. One in this lot was noticed with the contraction fold in the vicinity of the contractile bulbs, as noted under No. 2, *Sphyrna tiburo*. This specimen had a red pigment patch in the neck, a feature not present in all. July 26, few. July 27, few; contraction fold at anterior end of bulbs. Aug. 10, few.

13. *Otobothrium crenacolle* Linton.

1901.—July 15, 1; length 10 mm.; about 5 free segments each 3 mm. in length. July 18, 2. July 22, 6, from 4 to 7 mm. in length, posterior segments easily detached; later on same date, 1, small. Aug. 15, 1.

1902.—July 11, 29.

14. *Tetrarhynchus bisulcatus* Linton.

1901.—July 24, 1, about 20 mm. in length. July 25, 2. The larger of these two specimens appeared to have a longer collar than is usual in this species. The collar was also thin and undulate on the posterior border. The other specimen was smaller than normal for this species. Aug. 5, 12. Aug. 6, 1. Aug. 12, 3. Aug. 15, 2; these two specimens, like those taken on July 25, presented considerable differences from each other. The larger agreed with typical representatives of the species. The smaller, besides the difference in size, also differed in some of its proportions and in having sharper hooks than the larger. In each case the scolex was attached to but a short piece of the strobile. The following measurements, in millimeters, were made on the scolices after they had lain overnight in sea water to which a little formalin had been added. The dimensions of the smaller specimen are given first in each case: Length 0.35 and 0.7; length of bothria 0.36 and 0.5; diameter of collar 0.25 and 0.42; length of head and neck 0.64 and 0.7; length of bulbs 0.20 and 0.21; diameter of bulbs 0.09 and 0.11; diameter of proboscis, excluding hooks, 0.27 and 0.34, including hooks 0.44 and 0.47; length of longest hooks 0.013 in each. A single specimen collected on the next day, Aug. 16, agreed with the smaller of the two whose dimensions have just been given. Another found later on the same date was typical.

1902.—Aug. 14, 1.

15. *Synbothrium filicolle* Linton.

1902.—July 11, 3; encysted in submucous membrane of stomach. There were also numerous cysts in the stomach wall, in which no larvæ were found, some of which might have been due to this parasite. One much-elongated specimen was obtained from beneath the serous coat of the liver.

16. *Cysts.*

1902.—July 11, numerous in stomach wall between muscular layer and mucosa. Many of them were filled with degenerate tissue, but among these two specimens of No. 15 were found.

### **Sphyrna tiburo,** *Bonnet-head Shark.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901 | | |
| July 8 | 1 | Fragments of crustacea and one blue crab. |
| July 24 | 2 | Fragments of crustacea in great abundance, among them the abdomen of *Squilla mantis.* |
| July 25 | 2 | Fragments of blue crab and broken lamellibranch shells. |
| July 26 | 4 | Blue crab, other small crabs, and other crustacea. |
| July 27 | 1 | Blue crab. |
| August 6 | 2 | Crustacea, mainly shrimp. |
| August 7 | 1 | Crustacea (crabs and shrimp mainly) and fish (bait). |
| 1902. | | |
| July 18 | 1 | Crabs, shrimp. |
| July 25 | 1 | Crabs, small isopod, *Balanus*, sea-weed. |

The specimen taken on July 25, 1902, was a female with 8 young, each measuring 110 mm. in length.

## NEMATODES.

1. *Filaria galeata*, new species. [Figs. 17–19. See also fig. 20.]

Slender, hair-like, active worms of nearly uniform diameter, maximum diameter near posterior end, whence it tapers very gradually to the anterior end. Head with cushion-like hood (figs. 18, 19), œsophagus equaling about one-eighth the length of the worm, tapering uniformly from base to point just in front of nerve-ring, where there is an offset, thence cylindrical to mouth; diameter of œsophagus at base about twice what it is at the anterior end.

Posterior end of female conical-pointed; of male provided with lateral outgrowths of cuticle (alæ); papillæ not yet completely worked out (fig. 17). Four pairs of post-anal and about the same number of pre-anal papillæ were seen. The posterior end of the male has a strong tendency to coil into a spiral when placed in the killing fluid. Some, even, which were killed in a mixture of glacial acetic acid and absolute alcohol and kept straightened out by manipulation, still coiled into a spiral at the posterior end.

The spicules were not seen extruded in any of the specimens from the bonnet-head, but one from the small dolphin (fig. 20) had the spicule projecting, when it was seen to be modified at the distal end by lateral wings so as to resemble the fluke of an anchor.

The largest specimen measured was 35 mm. in length and 0.17 mm. in greatest diameter.

Dimensions of a male in acetic acid: Length 35; diameter of head, not including appendage 0.04, at middle of body 0.17, at anal aperture, not including alæ 0.11; of œsophagus, anterior 0.03, middle 0.05, at base 0.07; length of œsophagus 4.2, of longer head appendage 0.14; breadth of head appendage 0.1; distance from anterior end to nerve-ring 0.45; distance of anal aperture from posterior end 0.25.

Dimensions of ova in this species 0.04 and 0.02 mm. in the two principal diameters.

1901.—July 24, 9. July 25 and 26, numerous. July 27, few. Aug. 6, numerous. Aug. 7, 20.

1902.—July 18, 6. July 25, numerous.

2. *Rhynchobothrium plicatum* sp. nov. [Figs. 132–140.] From spiral valve.

Strobile slender, active, with tendency to coil up when compressed. Bothria about as broad as long, their bases not approximate; neck more or less elongated, very contractile, cylindrical, usually with a conspicuous collar-like fold at the contractile bulbs, always enlarging at the bulbs and usually narrowing again behind them. A patch of red pigment is usually present in the neck in front of the bulbs,

The contractile bulbs are pyriform or oval, and the retractor muscle, in those cases where the proboscis was retracted, could be seen lying in folds at the posterior end of the bulb. Sheaths and proboscides long. The proboscides are swollen at the base as in *R. tumidulum* and *R. tenuispine.* The hooks, except at the base of the proboscides, perhaps agree rather better with the latter. Beyond the basal portions of the proboscides they are rather more densely clothed with hooks than in either of the above-named species. Besides, they are stouter than in *R. tenuispine* and a little stouter, longer, and more curved than in *R. tumidulum.*

The segments begin close behind the bulbs, where the strobile may be slightly moniliform. At first they are much broader than long, but they soon become longer than broad, increasing in length rapidly until they are four or five times as long as broad; posterior segments much elongated. Testes conspicuous in two longitudinal, median rows in maturing segments; cirrus long, tapering, and smooth. Vitellaria lateral, ovary two-lobed at posterior end of the segment; vagina opening at posterior side of cloaca, which is at about the posterior third of the lateral edge of the segment; ova longer than broad, and bearing bristles on their surface as in *R. tumidulum.* Mature segments when full of ripe ova are fusiform, swollen, and dark-brown.

Dimensions, in millimeters, life: Length of bothria 0.32; breadth about the same; length of head and neck 1.43; length of contractile bulbs 0.32; length of posterior segments 3; diameter of neck 0.17; ova 0.05 and 0.02 in the two principal diameters; diameter of swollen base of proboscis 0.03.

The preserved specimens are about 10 mm. in length. Since the posterior segments separate rather easily, the actual length is doubtless greater than this.

Following are measurements of preserved material: Length of head and neck, one specimen 0.8, of another 1.28; contractile bulbs in three specimens 0.14 by 0.07, 0.17 by 0.08, 0.18 by 0.06, length and breadth respectively; diameter of proboscis excluding hooks 0.015, including hooks 0.027; tumid base, excluding hooks 0.024; length of longest hooks 0.01. One specimen was seen which had the blastocyst still attached. It agreed with specimens found in the sharp-nosed shark. (See No. 12 under *Scoliodon.*)

1901.—July 8, 1. July 24, few. July 25 and 26, numerous. July 27, few. Aug. 6, few. Aug. 7, 16.

1902.—July 18, 12. July 25, 10, one scolex adult, the others short and attached to blastocysts. Dimensions of one of the latter: length of head and neck 1; length of blastocyst 3.75; diameter of head 0.3, of neck just behind head 0.18, of blastocyst 1.2.

3. *Rhynchobothrium hispidum* Linton.

A single specimen from the spiral valve collected July 18, 1902, is referred with some hesitation to this species. The proboscides were not seen everted, and it is impossible to make out the arrangement of the hooks on the inverted proboscis.

Dimensions, in millimeters, of specimen mounted in balsam, compressed, neck contracted: Length of head and neck 0.6; length of bothrium 0.12; breadth of bothrium 0.12; breadth of neck 0.13; length of bulbs 0.3; diameter of bulbs 0.05; length of proboscis, estimated, 0.45; length of hooks 0.006 to 0.012.

The contractile bulbs are elongated, and there was a patch of red pigment in front of them.

### **Raja lævis**, *Barndoor Skate.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1902. | | |
| August 14 | 1 (small) | Shrimp. |
| August 18 | do | Shrimp and lamellibranches. |

The specimen obtained on Aug. 14 was collected by the Fisheries steamer *Fish Hawk*, station 7310, in 18 fathoms, off Cape Lookout.

CESTODES.

1. *Acanthobothrium paulum* Linton.

1902.—Aug. 14, 10, with free segments. Length, in 5 per cent formalin, 10 mm. Strobiles, especially the smaller ones, lanceolate. Aug. 18; 2.

### **Dasyatis say**, *Sting Ray.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| July 6 | 2 | Small bivalve mollusks, amphipods, and annelids. |
| July 8 | 5 | Small annelids. |
| July 9 | 1 | Amphipods and large number of annelids. |
| July 12 | 1 | Shrimps and annelids. |
| July 22 | 1 | Bivalve mollusks, foot of a gasteropod, shrimp, and sea urchin (*Arbacia*). |
| July 24 | 2 | Large quantity of a small annelid (*Nereis?*). |
| July 25 | 2 | Otoliths and crystalline lenses of fish, amphipods, annelids, and sand. |
| July 27 | 2 | Bivalve mollusks (*Solenomya*), annelids, sand. |
| 1902 | | |
| July 8 | 5 (medium) | Large numbers of siphons of a lamellibranch (*Tagelus*) with broken shells. |
| July 22 | 8 (medium) | Shrimp; one with intestine filled with shells of *Solenomya*. |
| July 23 | 7 (small) | Shrimp. |
| July 29 | 1 | Fish, crabs. |
| August 16 | 1 | Crabs, shrimp, siphons and "feet" of lamellibranch mollusk (*Tagelus*), shells of *Solenomya*. It would appear from the nature of the food of this ray and those collected on July 5 that the sting ray bites off siphon tubes of lamellibranchs without swallowing the shells. |
| August 18 | 1 (small) | Shrimp. |
| August 20 | do | Do. |
| August 26 | 1 | Shrimp, *Solenomya* and univalve shells, annelids, sand. |

All the rays were small, not varying far from 1 foot in length.

ACANTHOCEPHALA.

1. *Echinorhynchus pristis* Rudolphi.

1902.—July 29, 1, female; probably introduced with food.

CESTODES.

2. *Echeneibothrium* sp. [Fig. 82.]

1902.—Aug. 26, 1 scolex. The muscular proboscis (myzorhynchus) was very prominent, being thrust out while the worm was active, until its length was fully equal to that of a bothrium. The latter were leaf-like with crenate borders as in *Spongiobothrium;* water-vascular system conspicuous; two sinuous vessels near each lateral margin.

3. *Anthobothrium pulvinatum* Linton. [Fig. 125.] Spiral valve.

1901.—July 6, 2 and a fragment, longest specimen 50 mm. in length, variable in life. July 8, 17 obtained from five rays. July 9, 14 from one ray. Brief note is here made of the extraordinary diversity of form assumed by the bothria of the living worms. A bothrium when expanded and attached to the bottom of the dish is a nearly circular, thin and transparent disk. When so expanded, which is a form not usually assumed under ordinary conditions, the appearance is that of a peltate leaf. The edges may then roll in upon each other, and, the central portion contracting, there results a pyriform bothrium, the anterior end becoming more or less elongated. Sometimes the anterior end elongates into what looks like an auxiliary auriculate appendage. In some cases, especially when placed in fresh water, the bothrium becomes finely wrinkled or cushion-like and roseate. This is a rather common form and was the one assumed by the specimen which was first studied by me.

July 22, 1, with a few fragments. July 24, 16, with many free segments from two rays. July 25, numerous in each of two rays. July 27, 8, with ripe segments.

1902.—July 29, fragments of strobiles; no scolices. Aug. 16, 1. Aug. 26, 1.

4. *Rhinebothrium flexile* Linton.

1902.—Aug. 16, few, small; bothria not hinged, loculi numerous.

5. *Rhinebothrium* sp.; spiral valve.

1901.—July 12, numerous. These worms agree, in superficial characters at least, with *R. flexile*, except in the number of loculi on the bothria. In this particular they are nearer *R. minimum*. The bothria are distinctly slender and linear, pointed when extended, very versatile, with two rows of loculi, about twelve in each row, with an odd loculus at each end; pedicels cylindrical and somewhat elongate. The rows of loculi are interrupted at the middle of the bothrium, where the musculature is such as to give the appearance of a transverse hinge. The bothria thus agree closely with *R. longicolle*, but, while there is a short neck in this species, it is not separated from the body by a constriction as in the other. A red pigment spot was present in most of the specimens at the junction of the neck with the body. The pedicels and neck were covered with minute bristle-like spines. In some there was a faint indication of a terminal mouth, as in larval forms (*Scolex polymorphus*). In no case, however, either in living or preserved specimens, was anything seen like the myzorhynchus of the genus *Echeneibothrium*. First segments very short, subsequent segments squarish, then longer than broad; last segment usually tapering at the posterior end; margins finely crenulate; genital cloaca about anterior fourth on the margin; some strobiles moniliform; mature segments not seen. July 27, a few small specimens, with numerous detached segments. Two free segments probably belonging to this species were observed to be copulating.

1902.—July 22, few. Aug. 16, very numerous. Aug. 18, very numerous. Aug. 26, numerous. Bothria hinged at middle; five pairs of loculi and a single terminal loculus to each half, or twenty-two loculi to each bothrium. Found in spiral valve.

6. *Spongiobothrium variabile* Linton. Spiral valve.

1901.—July 22, 5 or more. When first seen, these worms had their bothria elongated so as to produce a very different appearance from the specimens upon which the genus was founded. They appear indeed to be very closely related to *Rhinebothrium*, the bothria being somewhat narrowly elongated, the loculi very numerous, but confined to the margins, as mentioned in the original description of the genus.

1902.—Aug. 16, 3, no mature segments.

7. *Paratænia medusia* Linton. Spiral valve.

1901.—July 6; numerous, small, not exceeding 4 mm. in length. These specimens agree closely with this species and are probably identical. It was observed that the segments projected slightly around the posterior border, a feature not noted before. July 24, several, small.

1902.—Aug. 16, 5. Aug. 18, few.

8. *Phyllobothrium foliatum* Linton. Spiral valve.

1901.—July 9, 1. July 22, 1902; 5. Aug. 26, 1.

9. *Anthocephalum gracile* Linton. Spiral valve.

1901.—July 22, several. July 27, several.

1902.—July 22, few. Aug. 16, 26.

10. *Lecanicephalum peltatum* Linton.

1901.—July 9, 1. July 24, several.

1902.—Aug. 18, 3.

11. *Onchobothrium uncinatum* Diesing. [Fig. 127.] Spiral valve.

1901.—July 8, 2, length 48 mm. in alcohol. Sections were made of the maturing segments in order to learn the meaning of what appeared to be a row of apertures along the median line of one of the flat surfaces of the strobile. It was found that they represented points at which the very voluminous vas deferens protruded some of its convolutions through the wall of the proglottis. This character was observed in others of this species later in the season. The arrangement of the reproductive organs and the musculature of the neck present some peculiarities in this species which must be left for a subsequent paper.

1901.—July 22, 3. July 27, 1, length 60 mm.

1902.—July 8, 2 scolices and 10 fragments of strobiles. Specimens not in good condition, probably due to the large number of broken shells in the intestines. July 22, 50 from one ray. July 23, few, the only species of entozoa found in the seven rays examined on this date. Aug. 18, 1. Small rays, as a rule, have few parasites.

12. *Acanthobothrium paulum* Linton. Spiral valve.

1901.—July 8, 2.

1902.—July 22, numerous. Aug. 16, 1. Aug. 26, numerous.

13. *Rhynchobothrium tumidulum* Linton. Spiral valve.

1901.—July 12, 1 seen among the numerous other small cestodes (No. 5, above).

14. *Rhynchobothrium hispidum* Linton. [Fig. 146.]

1901.—July 22, several; length 4.34 mm.

1902.—Aug. 16, 18, 20, few on each date. Aug. 26, a very few noted in dish with the very abundant *Rhinebothrium* sp. (No. 5) and *Acanthobothrium paulum*. There is red pigment usually present in this species, and since there is a small patch of this red pigment on each of the four proboscis sheaths and at the same level on each, it follows that two spots of red pigment are seen in any position in which the worm chances to lie.

15. *Rhynchobothrium tenuispine* Linton.

1901.—July 24, several.

1902.—Aug. 16, several. Aug. 18, few. These had comparatively strong spines on the neck, and on that account the name *hispidum* would be more fitting for them than for the individuals referred to No. 14. The proboscides, however, are armed with the characteristic minute hooks of this species. One case was observed where the proboscides were retracted so powerfully as to draw a considerable portion of each into the contractile bulb.

16. *Rhynchobothrium* sp. [Fig. 131.]

1902.—July 22, 1, scolex and first segments. This specimen had a narrow transverse band of red pigment behind the contractile bulbs. The retractor ribbons were unusually broad, each composed of a number of longitudinal fibers and originating from the posterior end of the long contractile bulb. Hooks of various shapes. Dimensions, life, compressed, in millimeters: Length of head and neck 8, of head alone 0.8; breadth of head 1.4; diameter of neck, behind head 0.7, at bulbs 1, behind bulbs 0.4; length of bulbs 3.45; diameter of bulb 0.22; distance from bulbs to first segment 0.7; length of first segment 0.11, breadth 0.45. Transverse striæ begin 0.4 mm. behind the bulbs.

17. *Cysts.*

1902.—July 8, 1 in liver, 2 in walls of intestine. These were filled with waxy degenerate connective tissue, and represent parasites which had been lodged in the tissues of their host for a long time.

### TREMATODES.

18. *Distomum vitellosum* Linton.

1902.—Aug. 20, 1, small and active, no ova.

### **Pteroplatea maclura,** *Butterfly Ray.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| July 9 | 1 | Contents of alimentary canal completely digested. |
| July 12 | 1 | Fish in stomach; fragments of crustacea and annelids in intestine. |
| July 15 | 1 (small) | Alimentary canal empty; no entozoa. |
| July 31 | 2 | Only mucus in alimentary canal. |
| August 1 | 2 (small) | Crystalline lens of small fish; sand. |
| 1902 | | |
| July 7 | 2 (small) | Shrimp. |
| July 11 | 1 (small) | Food completely digested; no entozoa. |
| July 17 | 2 (small | Fish; no entozoa. |
| July 18 | 5 | Fish. |
| July 22 | 3 | Fragments of *Solenomya* in one. |
| July 29 | 2 | Material digested. |
| July 31 | 1 | Fragments of an annelid. |
| August 4 | 1 | Alimentary canal empty; no entozoa. |
| August 11 | 2 | Fish; no entozoa. |
| August 19 | 2 | Fish (black sea bass). |
| August 20 | 5 | Fish, lamellibranchs. |
| August 21 | 1 | Small crustacea, megalops, copepods. |
| August 22 | 1 | Fish; no entozoa. |
| August 26 | 2 | Do. |

### NEMATODES.

1. *Immature nematodes.*

1902.—July 7, 1. The only entozoan found in the two rays examined on this date was an exceedingly minute nematode in the intestine. It was doubtless introduced with food, and can not be counted as a proper guest of the ray. Length 1.3; length of œsophagus 0.32; length of postanal region 0.19; diameter 0.045.

### CESTODES.

2. *Scolex polymorphus* Rudolphi.

1901.—July 31, few and small, in alimentary canal.

3. *Acanthobothrium paulum* Linton. [Fig. 128.]

1901.—July 12, 3, small, about 5 mm. in length; free segment 1.47; cirrus 0.38, long and spinose. July 31, 4; strobiles when subjected to slight pressure became moniliform and the posterior segments separated. Length of one 3.6 mm., length of last segment 0.45 mm. Aug. 1, 3.

1902.—July 18, 1 scolex and a few fragments, not in good condition. July 22, several. Aug. 20, 2 and several loose segments. Aug. 21, 5 and a few loose segments. Length of one 6; length of posterior segment 1.12; breadth 0.3, varying with different states of contraction. Reproductive cloaca at posterior fourth; neck distinct. About 20 distinct segments were counted in the longest specimen; the first 10 of these were short, the remainder were more or less elongated. A free segment, length 1.5, breadth 0.6 (compressed) had the reproductive cloaca 0.2 from the posterior end.

4. *Rhynchobothrium* sp.

1901.—Aug. 1, 3 small oval cysts outside of stomach wall.

5. *Synbothrium filicolle* Linton.

1901.—July 9. The only entozoa observed in the ray examined on this date were a few cysts on the viscera, from one of which a species of *Synbothrium* was liberated. Type with slender straightish hooks on proboscides.

1902.—July 29, 1, with beginning segments, small. The segments were slender and immature. Aug. 19, 1, not in good condition; scolex with blastocyst attached. Although these specimens were obtained from the intestine of the ray, it is doubtful whether the butterfly ray is the proper final host of *Synbothrium*.

### TREMATODES.

6. *Distomum* sp. [Fig. 210.]

1902.—July 18, 1, immature in cyst. Dimensions, life, in millimeters: Length 1.35; breadth, anterior 0.18, at ventral sucker 0.38, near posterior end 0.53; diameter of oral sucker 0.8, of ventral sucker 0.12, of pharynx 0.12. Probably introduced with food, and the cyst yields more slowly to the digestive fluids than do the tissues in which it was embedded.

This is probably the young of *D. tenue*, or an allied species.

## **Galeichthys milberti**, *Sea Cat-fish.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| July 8 | 3 | Crustacea (shrimps). |
| July 20 | 1 | Stomach distended, contained relatively large vertebræ and other bones of fish, part of arm of a large blue crab, one sea-cucumber (*Thyone*). The intestine was filled with white, granular chyle. |
| July 25 | 3 | Mainly vegetable débris with spines of annelids and sand. |
| July 27 | 2 | Lamellibranch shells (*Solenomya*), annelids. |
| August 5 | 1 | Shrimp, bivalve mollusks, and fish. |
| August 8 | 1 (small) | Shrimp and fish. |
| August 20 | 1 | Fish, bivalve mollusks, odontophore of gastropod. |
| August 22 | 1 | Food completely digested into chalky material, which effervesced briskly with acid. |
| August 25 | 1 | Fish, crabs, lamellibranch mollusks. |
| 1902. | | |
| July 18 | 1 | Fish (crystalline lenses, etc.), annelids, small gasteropods. |
| August 20 | 2 | Fish, shrimp, annelids, sand. |

### NEMATODES.

1. *Small nematodes.*

1902.—July 18, fragment of ovary with segmenting ova; length 14 mm; diameter 0.5; ova 0.047 by 0.025. Also several small nematodes in alimentary canal; in poor condition; evidently introduced with food and not in proper final host.

2. *Heterakis foveolata* Rudolphi.

1901.—July 8, 1 male; length 10 mm; length of œsophagus 1.4; diameter of head 0.21, middle 0.31, at anal aperature 0.17; distance of anal aperature from posterior tip 0.34. In side view there were seen two post-anal and three pre-anal papillæ. Aug. 5, 1 male, in poor condition.

See remarks on this genus in introduction.

### CESTODES.

3. *Rhynchobothrium* sp.

1901.—July 20, 1, an oval cyst on viscera about 5 mm. in length, glistening, translucent, thin walled, tense, supplied with blood vessels. Blastocyst oval; length 5 mm.; breadth 2.5 mm.; translucent, with larva visible at one end. Length of larva 5.74 mm., to base of contractile bulbs 2.38 mm. Bothria at rest; length 0.42 mm.; breadth 0.49 mm., with prominent, raised border, emarginate posteriorly. Length of longest hooks 0.022 mm. July 25, 1 specimen agreeing with above. The larva in life had a peculiar collar-like structure on the neck immediately behind the head, which was probably due to unequal contraction of the tissues of the neck, as there is but a slight notch taking its place in the preserved specimen. See No. 3, under *Scomberomorus regalis.*

4. *Otobothrium crenacolle* Linton.

1901.—July 8, numerous small cysts about 2.5 mm. in length under serous coat of stomach and intestine. From one of these a pyriform blastocyst was liberated, 1 mm. in length and 0.3 mm. in diameter. The calcareous bodies in the parenchyma of the blastocyst were very abundant and separable into two groups. The larger bodies measured from 0.08 to 0.11 mm. in diameter, the smaller and more numerous 0.015 mm. and less, with scarcely any intermediate sizes. Aug. 5; 1 specimen, encysted.

5. *Synbothrium* sp. See No. 10, under *Cynoscion regalis.*

1901.—July 25, 8 elongated cysts with blastocysts and larvæ. The hooks on the proboscides were of different shapes and sizes, but all were more or less recurved. July 27; 2 elongated cysts on viscera, same type as above. Another cyst with calcareous deposit around it can not be identified on account of degeneration of its contents. Aug. 23, 2 cysts, 1 on viscera near rectum, the other on the dorsal wall of the abdominal cavity.

6. *Scolex polymorphus* Rudolphi.

1901.—July 20, 12 of these larval cestodes, obtained from the cystic duct near its junction with the intestine. These resemble forms found in similar situations in *Cynoscion* and *Paralichthys.* The specimens contracted freely between 4 and 8 mm. in length. At rest, with bothria retracted, the length was about 1.2 mm. There was no indication of costæ on the bothria nor of the red pigment patches often noted in these larval cestodes. Aug. 8; in alimentary canal. No entozoa were found in the fish examined on Aug. 20 and 22.

7. *Cyst.*

1902.—July 18, apparently blastocyst of a *Rhynchobothrium;* scolex not developed. Dimensions in millimeters: Length of cyst 5; diameter 2; blastocyst, length 7.5, diameter 1.5. Aug. 20, piece of cestode blastocyst, but no larva.

### TREMATODE.

8. *Distomum* sp. [Fig. 209.]

1902.—Aug. 20, 1, spinose, immature. Dimensions, life, in millimeters: Length 1.8; breadth 0.6; diameter of oral sucker 0.16, of ventral sucker 0.15; pharynx, length 0.08, breadth 0.04. This may be a young specimen of No. 4, under *Symphurus plagiusa.*

### Anguilla chrisypa, *Eel.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| August 2 | 1 | Alimentary canal empty, except fragment of fish which had been used as bait. |
| August 21 | 1 | Stomach empty; material in intestine completely digested. |

NEMATODES.

1. *Heterakis foveolata* Rudolphi.

1901.—Aug. 2, 2, male and female, the latter with ova undergoing segmentation. Four and eight-celled stages of development were noted. See remarks on *Heterakis* in the introduction.

CESTODES.

2. *Scolex polymorphus* Rudolphi.

Aug. 2, few, found in intestine.

3. *Dibothrium larva.*

Aug. 21, 1, small slender blastocyst on viscera.

4. *Rhynchobothrium* sp.

Aug. 21, 1 larva from cyst on viscera; not very distinctly seen, but appears to be of the type characterized in these notes as small with relatively long hooks. See introduction.

### Leptocephalus conger, *Conger Eel.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1902. | | |
| July 21 | 1 (length 18 inches) | Contents of alimentary canal completely digested. |
| July 24 | 1 (length 36 inches) | Fish and gasteropods (*Urosalpynx*). |
| July 25 | 1 (length 12 inches) | Fish (pipe-fish). |
| August 19 | 1 | Fish and shrimp. |
| August 20 | 1 | Alimentary canal empty. |
| August 25 | 4 | Fish. |

NEMATODES.

1. *Heterakis foveolata* Rudolphi.

1902.—July 25, 1, male. Aug. 20; 1, male. Aug. 25; 4. See remarks on this genus in introduction.

CESTODES.

2. *Scolex polymorphus* Rudolphi.

July 24, few, small, no costæ nor red pigment. Aug. 19, not numerous. Aug. 20; few, very small. Aug. 25, few.

3. *Cestode cysts.*

July 24; in intestinal wall, blastocysts, no scolices.

TREMATODES.

4. *Distomum grandiporum* Rudolphi.

Aug. 25, 2.

5. *Distomum vitellosum* Linton.

Aug. 20, 1, small; in poor condition.

### Elops saurus, *Big-eyed Herring.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901.<br>August 14 | 1 | Six large shrimp (*Penæus*) in stomach. |

#### CESTODES.

1. *Rhynchobothrium* sp. [Figs. 99, 100*a*.]

Two in oval cysts on viscera. Dimensions, life, in millimeters: Cyst, length 5, breadth 3; blastocyst, length 5, breadth 2.5. Larva, flattened under cover-glass, length 7.35; breadth of head 0.9; length of bothria 0.77; length of head and neck to base of bulbs 4.2; length of bulbs 0.5; diameter of proboscis near base 0.062 without and 0.078 with hooks, at middle 0.04 without and 0.068 with hooks; length of longest hooks 0.03. During life the larva was very active, the bothria changing shape without pause. Head broader than long, water-vascular system conspicuous, a labyrinth of vessels in the head and extending halfway or more to the margins of the bothria.

Hooks for the most part rather long and slender, but moderately curved and not presenting a great variety of shape or size.

A specimen with hooks much like these was found in *Scomberomorus maculatus.*

### Brevoortia tyrannus, *Menhaden, Fat-back.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901.<br>July 23 | 1 | Alimentary canal filled with greenish mud, consisting of sand and vegetable débris; diatoms and algæ of many different kinds. Foraminifera with spherical shells, abundant, also *Discorbina;* small fragment of copepod; numerous spines and spicules not identified.<br>See Peck's valuable paper on the Food of the Menhaden, U. S. Fish Commission Bulletin for 1893, pp. 113-124, Pls I-VII; Bulletin for 1895, pp. 351-368. |
| 1902.<br>July 23 | 1 | Food not noted. |
| August 7 | 4 (60 mm.) | Intestines packed with many kinds of copepods. |

#### NEMATODES.

1. *Immature nematode.*

1901.—July 23, 1, small; type with diverticulum on both intestine and œsophagus; see introduction.

#### TREMATODES.

1. *Dactylocotyle* sp. [Fig. 151.]

1902.—July 23, 1, an imperfect specimen from the gills.

2. *Distomum appendiculatum* Rudolphi. [Fig. 160.]

Specimen in poor condition and determination of species uncertain. Aug. 7, 1902; 1, small, testes small, ovary close to testes; vitellaria two, small, not lobed, close to ovary; length 0.63; breadth 0.18; diameter of oral sucker 0.05, ventral sucker 0.10; ova 0.025 by 0.018.

3. *Distomum pyriforme* Linton.

1902.—Aug. 7, 1, small, partly macerated; length 1.05, no ova.

#### PARASITIC COPEPODS.

4. *Brachiella* sp.

1902.—July 23, 1, attached among gill-rakers.

### **Stolephorus brownii**, *Striped Anchovy.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1902. | | |
| July 16 | 1 (112 mm.) | Glistening white chyle, in which little could be recognized; a few spines and other fragments of annelids, and foraminifera. |
| July 17 | 10 | Mainly copepods, zoæa, and spines of annelids. |
| July 30 | 1 | Small shrimp and other small arthropods. |

NEMATODES.

1. *Immature nematodes* (*Ascaris*).

1902.—July 17, 1; common type, diverticulum from both œsophagus and intestine.

CESTODES.

2. *Scolex polymorphus* Rudolphi.

July 16; numerous; very small, one costa and red pigment. July 17; several.

TREMATODES.

3. *Distomum* sp. [Fig. 166.]

This is a young form of some distome related to *D. velipórum.*

1902.—July 16, a small, immature distome seen while the food was being examined under the compound microscope. Dimensions, life, in millimeters: Length 0.25; breadth 0.16; diameter of oral sucker 0.08, of ventral sucker 0.10. July 17, 1; apparently same species, but a larger specimen; length 1.2; breadth 0.6; diameter of anterior sucker 0.14, of ventral sucker 0.28.

4. *Gasterostomum gracilescens* Rudolphi.

1902.—July 30, few, encapsuled on viscera.

See under *Menidia menidia* and *Tylosurus marinus.*

### **Synodus fœtens**, *Lizard Fish, Sand Pike.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| July 31 | 1 | Alimentary canal empty, except mucus. |
| 1902. | | |
| July 7 | 1 ([illegible] mm.) | Food not noted. |
| July 17 | 1 (112 mm.) | Small crab. |
| July 19 | do | Food completely digested. |
| July 22 | 1 (125 mm.) | Do. |
| July 23 | do | Do. |
| July 25 | 3 (175 mm.) | Fish. |
| July 30 | 2 (small) | Shrimp, small annelids. |
| July 31 | 1 (small) | Fish. |
| August 1 | 2 (small) | Do. |
| August 7 | 1 (small) | Fish (silverside). |
| August 15 | 12 (small) | Food completely digested. |
| August 16 | 3 (small) | Fish, spatangoid sea urchin. |
| August 18 | 1 (30 cm.) | Food digested. |
| August 19 | 2 (small) | Fish. |
| August 20 | 6 (small) | Fish and shrimp. |
| August 25 | 2 (30 cm.) | Food digested. |

ACANTHOCEPHALA.

1. *Echinorhynchus proteus* Westrumb.

1901.—July 31, 2. A few nodules were noticed on the external surface of the intestine, which were at first thought to be cysts due to some larval cestode or nematode. They proved to be due to the head of this worm, which had penetrated the intestinal wall.

2. *Echinorhynchus sagittifer* Linton.

1901.—July 31, 1, from body cavity, on viscera.

NEMATODES.

3. *Immature nematodes* (*Ascaris*).

1901.—July 31, 1 from viscera. The embryonic cuticle was in process of sloughing off. The specimen was of the kind which has a slender diverticulum of the œsophagus and a short anterior prolongation of the intestine—the type found in a large number of hosts both seasons.

1902.—July 19, few.

CESTODES.

4. *Scolex polymorphus* Rudolphi.

1901.—July 31, numerous. These were found in large numbers in the cystic duct, where they were attached by their heads to the mucous membrane in two clusters, as noted in former papers, in the squeteague. When the fish was first opened numerous small white bodies were seen beneath the serous coat of the stomach. A piece of the stomach wall was cut out and placed in sea water. When it was examined a few hours afterwards the parasites had crept out. They all appeared to be *S. polymorphus*, but smaller than those from the cystic duct.

This is the only instance in which I have found these forms occupying this position.

1902.—July 17, several; no costæ nor red pigment. July 9, 22, few. July 25, several; some appeared to have rudimentary segments. July 30, 31, several. Aug. 1, several. Aug. 15, numerous. Aug. 16, few. Aug. 18, several; large and small together in intestine. Aug. 19, several. Aug. 20, several, small. Aug. 25, few, small.

5. *Rhynchobothrium* sp.; probably encysted stage of *R. longispine*.

1902.—July 19, a single scolex found free in the intestine. The hooks are much like those of the frequently recurring form characterized in these notes as small, with relatively large hooks. This specimen had a patch of red pigment in the neck, while the blastocyst was attached to the larva.

6. *Dibothrium tortum* sp. nov. [Figs. 119–124.]

Scolex of the *Monobothrium* type—that is, there was no indication of bothria, even in transverse sections.

Color of body dead white; head and neck somewhat less opaque.

Anterior end subcylindrical or moderately compressed, sometimes spiral; when placed in killing fluid there is a strong tendency to assume a spiral or twisted shape, like a cork-screw or an augur. This tendency was observed to be characteristic of all—so much so that I did not succeed in getting an entire strobile free from kinks. Body proper flattened, tanæiform, nearly uniform in breadth, with a tendency to break into fragments of irregular length, but no indication of segments. The sets of reproductive organs follow each other closely, and the reproductive openings lie along the median line of one of the flat faces of the strobile. The vaginal opening and the posterior border of the spherical cirrus-bulb are contiguous on the median line. The ovary is laterally elongated and lies posterior to the other reproductive organs of its set. The uterus lies in front of it and passes alternately right and left of the reproductive aperture. Testes lateral, surrounded by the vitellaria, which occupy the greater part of the periphery of the body. Dimensions, life, in millimeters: Diameter of head 0.75; breadth of body 2; ova, elliptical, 0.054 by 0.036 in the two principal diameters. Approximate length of strobile 45. The ova in an alcoholic specimen measured 0.045 by 0.027.

1901.—July 31, 1 fragment.

1902.—July 17, several, attached to mucous membrane of their host, but easily detached. July 19, 3. July 22, few. July 25, several. July 30, 1 or more scolices, several fragments of strobile. July 31, several. Aug. 1, several. Aug. 7, 2. Aug. 15, 2. Aug. 16, several. Aug. 18, abundant. Aug. 19, 20, several fragments. Aug. 25, numerous.

The fragments of strobile, both in life and preserved, are much folded, frilled, and twisted.

These worms are referred to the genus *Dibothrium* (*Bothriocephalus*) provisionally. The scolex would place them in the genus *Monobothrium*, while the general character of the strobile is that of *Dibothrium*.

TREMATODES.

7. *Distomum monticellii* Linton. [Fig. 155.]

1901.—July 31, 1.

1902.—July 7, fragment. July 17, 9; length 5.1 mm; general color of larger specimens red-brown; smaller specimens, without ova, paler. July 19, 5. July 22, 1. July 23, 1. July 25, 12. July 30, 6. July 31, several. Aug. 1, 5. Aug. 7, 2. Aug. 15, 1; probably same species as others, but more mature; intestine slender and not traceable in places, extending into appendix; intestines of others voluminous. Aug. 16, several. Aug. 19, 9 large, 1 small, immature. Aug. 20, numerous. Aug. 25, 10.

The specimen collected in 1901 was without ova; the two vitellaria had each three blunt digitate lobes; the intestine was yellow, excretory vessels dark by transmitted light, opaque white by reflected light.

8. *Distomum tornatum* Rudolphi.

1902.—Aug. 16, 1 and fragments; fragments of large, thick distomes, intestine dark brown and extending into posterior end; ova 0.018 by 0.011 mm. Aug. 25, 9, larger ones 10 mm. in length, reddish flesh color. Aug. 16, 19, few on each date.

### **Fundulus majalis**, *Killi-fish*, *Rock-fish*.

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1902. | | |
| July 7 | 3 | Annelid fragments. |
| July 8 | 15 | Mainly shrimp and small lamellibranchs. |
| July 16 | 13 | Small shrimp, amphipods, copepods, lamellibranchs, and young gastropods. |
| July 17 | 1 | Sand and many small amphipods in stomach; no entozoa. |
| July 21 | 1 | Fragments of crustacea, pieces of lamellibranch shells, annelid setæ, and sand. |
| July 22 | 9 | Shrimp. |
| July 23 | 1 | Small crustacea and broken shells. |
| August 4 | 9 | Annelids, solenomya, and other small lamellibranchs. |
| August 7 | 2 | Not noted. |
| August 15 | 9 | Mainly minute diptera; also small lamellibranchs, amphipods, and sand; no entozoa. |

#### ACANTHOCEPHALA.

1. *Echinorhynchus pristis* Rudolphi.

1902.—Aug. 7, 1 small male.

#### NEMATODES.

2. *Immature nematodes* (*Ascaris*)

Type with diverticulum on both intestine and œsophagus.

1902.—Aug. 7, few.

#### CESTODES.

3. *Tænia* sp. (encysted). [Figs. 85, 86.]

This is the encysted stage of a form whose adult stage will be found in some species of fish-eating bird.

The cysts are white and occur for the most part on the mesentery. When these were opened elongated larvæ were liberated, in most of which the characteristic four suckers and rostellum with its crown of hooks were found to be developed. In all cases the suckers and rostellum were invaginated, but could be seen plainly when the larva was flattened and viewed with transmitted light.

Dimensions of larva, life, moderately compressed, in millimeters: Length 5.5; breadth at anterior end 0.75, from whence the body tapers to the posterior end; sucker, length 0.16, breadth 0.15; length of invaginated head 0.9; length of rostellum, measured from actual anterior edge of sucker, 0.33; length of hooks 0.22.

Two scolices were obtained from one of the larger cysts; one of these had a constriction just back of the anterior end. In this one neither suckers nor rostellum had yet developed. The longitudinal vessels were conspicuous and the parenchyma was coarsely granular from the presence of calcareous bodies.

The cysts are soft and white and contain a whitish granular semifluid material, which is not unlike parenchyma and surrounds the larva. They are in this particular like the cysts found by the author in *Salmo mykiss*, containing larvæ of *Dibothrium cordiceps* (Bull. U. S. Fish Commission for 1889). Sections show these cysts to have rather thick walls composed of somewhat loose connective tissue. The larvæ lay at one side of the cavity closely adherent to the wall of the cyst. The cavity of the cyst sectioned contained also small masses of connective tissue, which were evidently derived from the wall of the cyst.

July 7, 8, 16, 21, and 23, a few found on each date. It has seemed best to use the old and more comprehensive generic name for these immature worms.

TREMATODES.

4. *Distomum globiporum* Rudolphi. [Fig. 159.]

July 22; 3; placed provisionally in this species. Dimensions, life, in millimeters: Length 2.25; maximum diameter 0.5; diameter of oral sucker 0.18, of pharynx 0.10, of ventral sucker 0.18; ova 0.09 by 0.07.

5. *Monostomum* sp. [Fig. 217.]

Small, oval. Dimensions of living specimens, compressed, in millimeters: Length 1.12; greatest breadth 0.33; diameter of oral sucker 0.10, of genital sucker 0.08, of pharynx 0.05; ova 0.025 by 0.014. This is the same species as No. 7 under *Menidia menidia*.

### **Fundulus heteroclitus**, *Killi-fish.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1902. | | |
| July 22 | 1 | Ostracodes and diatoms; large proportion of latter circular. |
| August 1 | 1 | Not noted; no entozoa. |

CESTODES.

1. *Scolex polymorphus* Rudolphi.

July 22, few, small; seen in piece of intestine which was being examined for food contents.

### **Tylosurus marinus**, *Gar.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| August 1 | 3 (small) | Contents of alimentary canal almost completely digested. With the help of the compound microscope a few fragments of crustaceans were found. |
| 1902. | | |
| July 22 | 1 | Alimentary canal empty. |
| July 24 | 1 | Do. |
| July 31 | 2 | Spines of sea urchin (*Moira*) in one. |
| August 1 | 2 | Fish. |
| August 7 | 1 | Fish (silverside). |
| August 11 | 1 | Fragments of annelids. |
| August 15 | 5 | Fish, amphipods. |
| August 20 | 4 | Fish, shrimp. |
| August 22 | 1 | Shrimp. |
| August 25 | 1 | Fish, shrimp. |

NEMATODES.

1. *Immature nematode* (*Ascaris*).

Type with elongated basal portion of œsophagus and corrugated post-anal region.

1902.—Aug. 7, 1.

2. *Minute nematode.*

1902.—July 31, 1; curved like the letter C; probably related to the minute forms found in *Leiostomus*.

CESTODES.

3. *Scolex polymorphus* Rudolphi.

1902.—July 31, few, small; 2 red pigment spots present. Aug. 20, few, small.

TREMATODES.

4. *Distomum tornatum* Rudolphi.

1902.—July 22, 3; in cysts about 5 mm. in diameter in the intestinal wall. Cysts dark colored, almost black on account of accumulation of pigment. The diatomes were light pink or flesh color and very active; the neck could be stretched until it was filiform or contracted until the two suckers were brought together. The specimens, while of good size, were immature, no ova being present. Dimensions, in millimeters, of flattened specimen: Length 6, neck (contracted) 1; diameter, oral sucker 0.41, ventral sucker 0.96. Aug. 1, 2, immature. Aug. 11, several; large but without ova. Aug. 15, 2; large, no ova. Aug. 20, 3 large and 2 small, flesh color, no ova. Aug. 25, 2, no ova.

5. *Distomum vitellosum* Linton.

1902.—Aug. 7, 1; specimen in poor condition; ova few, 0.086 by 0.054, segmenting.

6. *Gasterostomum gracilescens* Rudolphi.

See under *Menidia menidia*, etc.

1901.—Aug. 1, numerous; fusiform, pale red to colorless; not much variation in size. One measured 1.44 mm. in length and 0.56 mm. in greatest breadth.

1902.—July 31, 1. Dimensions, life, compressed: Length 1.4; maximum breadth 0.65; transverse diameter, anterior sucker 0.33; mouth 0.10; ova 0.018 by 0.011. Aug. 1, 12. Aug. 11, numerous. Aug. 15, 30. Aug. 20, numerous. Aug. 22, numerous.

Small, minutely spinose, of very various shapes, translucent white to orange yellow, depending on relative abundance of ova. The anterior end in some was curved ventrad, turning the sucker into a hood-like organ.

These worms agree closely with Olsson's figures and descriptions of forms which he refers with some doubt to this species. The same species was found in this host at Woods Hole, Mass., but was not identified. (Bulletin U. S. Fish Commission for 1899, pp. 277, 298, pl. XLI, fig. 91, and p. 442, pl. XXXIV, figs. 367, 368.)

### COPEPOD PARASITES.

7. *Lernanthropus* sp. From gills.

These very singular forms are certainly appropriately named in their generic title; for not only do the males suggest the human form but the females, on account of a skirt-like prolongation of the abdomen for the protection of the ova, simulate with absurd accuracy the same as modified by the attire commonly worn by women in civilized communities.

1902.—July 22, 1; male. Aug. 1, 3; females. Aug. 11, 5 females, 2 males. Aug. 15, 9 females, 3 males. Aug. 20, numerous; males and females; Aug. 22, 4 females, 7 males. Aug. 25, 7 males, 3 females. Length of male 1.73, of female 2.85 mm.

8. *Copepod parasite.* From gills.

1902.—Aug. 1, 1; white with single, Cyclops-like eye-spot of red pigment; female with white egg masses. Length, including caudal spines 2.1 mm. Aug. 11, 20; 1 on each date.

## **Tylosurus raphidoma**, *Needle-fish.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901.<br>August 26.......... | 1, about 3 feet in length. | Fish (menhaden), and a few small crustaceans. |

### NEMATODES.

1. *Immature nematodes* (*Ascaris*). [Figs. 29, 30.]

Two; from cysts on viscera. These belong to the type which is characterized in these notes as having a short anterior diverticulum of the intestine and a slender diverticulum from the base of the œsophagus.

Dimensions, life, in millimeters: Length 11; diameter, middle 0.3, tapering about equally in each direction; length of œsophagus, not including the posterior globular portion, 0.95; of globular portion 0.1; diameter of œsophagus 0.1; length of diverticulum of œsophagus 0.8, diameter of one 0.05; length of diverticulum of intestine 0.3; diameter at anal aperture 0.11; distance of anal aperture from posterior end 0.17.

One orange-yellow cyst filled with waxy, degenerate tissue also probably due to nematode.

### CESTODES.

2. *Otobothrium* sp. [Figs. 102–109.]

In muscular tissues, very numerous, generally distributed through the muscles of the body, a few close beneath the skin, by far the greater proportion in the deep muscles. Of the latter a few were in the abdomonal muscles, but most abundant laterally along the vertebral column. These flesh parasites are blastocysts containing larvæ. They have doubtless penetrated the flesh from the alimentary canal. When placed in sea water they were very active, extending and contracting, and assuming a great variety of consecutive shapes and dimensions. The blastocyst which was sketched while living measured about 8 mm. in length, about half the length being taken up with the anterior enlarged part. The larva when liberated from the blastocyst is also quite active. Its length, at rest, was from 4 to 5 mm. After the larva was removed from the blastocyst the latter was much more active than the former, being, in fact, altogether as active as it was before it was damaged.

The neck of the larvæ, between the bothria and the contractile bulbs, was covered with rather thick and fleshy spines 0.08 mm. in length, so that the surface under moderate magnification is rough.

The proboscides are armed with hooks of various sizes and shapes; diameter of a proboscis near the base, 0.18 mm. excluding and 0.28 mm. including hooks; length of the longest of the large recurved hooks 0.14 mm. Other dimensions, life, in millimeters: Length 4.5; breadth of head (marginal view of bothria) 1.4; length of bothrium 1.4; contractile bulbs, length 1.4, breadth 0.4.

There were two varieties of these larvæ. The longer kind remained firmly attached to the blastocyst, which was not the case with the shorter kind. The posterior end of the neck is emarginate, with a deep rounded notch on each side. This notch in the elongated specimens appeared to be opposite the intervals between the two bothria, while in the shorter specimens it was opposite the bothria. The accessory bothrial organs are small and somewhat crescentic.

On account of the comparatively large size of these larvæ it was naturally suggested that they might prove to be the encysted form of the new species (*O. insigne*) found in the dusky shark. A comparison of the proboscides of the two forms, however, makes this very doubtful.

### **Tylosurus caribbæus**, *Gar-fish.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1902.<br>August 15 | 1 | Small crustacea and fragments of insects which seemed to be small crickets. |

COPEPOD PARASITES.

1. *Copepod parasite.* From gill.

One from gills; same form as No. 8 under *T. marinus;* white with single median eye-spot of red pigment.

### **Hyporhamphus roberti**, *Common Halfbeak.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1902.<br>August 11 | 1 | Algæ, sea lettuce; contents of intestine green. |
| August 12 | 1 | Do. |
| August 16 | 1 | Do. |
| August 21 | 1 | Food almost exclusively algæ, color of contents of stomach and intestine green. Among the fragments of green algæ were a few young crustaceans in the megalops stage, and a *Caprella*. These had evidently been taken while the fish was feeding on the algæ. |

NEMATODES.

1. *Immature nematodes* (*Ascaris*).

Type with diverticulum to both intestine and œsophagus.

1902.—Aug. 11; 1.

CESTODES.

2. *Scolex polymorphus* Rudolphi.

Aug. 12, few, small.

3. *Cestode larva.*

Aug. 16, 1; looks like young *Dibothrium.*

**Siphostoma fuscum**, *Common Pipe-fish.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1902. | | |
| July 7 | 7 | Not noted. |
| July 9 | 32 | Do. |
| July 14 | 8 | Fragments of small crustaceans. |
| July 15 | 3 | Not noted. |
| July 16 | 1 | Do. |
| July 17 | 1 | Do. |
| July 19 | 5 | Not noted; no entozoa. |
| July 21 | 1 | Completely digested; looked like vegetable débris; no entozoa. |
| July 23 | 8 | Not noted. |
| July 24 | 1 | Not noted; no entozoa. |
| July 25 | 4 | Amphipods and ostracodes. |
| July 29 | 4 | Completely digested. |
| August 4 | 5 | Small crustacea. |
| August 6 | 3 | Do. |
| August 7 | 1 | Not noted; no entozoa. |
| August 12 | 4 | Copepods and minute spatangoid spines. |
| August 20 | 2 | Not noted. |

CESTODES.

1. *Scolex polymorphus* Rudolphi.

1902.—July 14; few; bothria with two costæ and rudiment at anterior end, suggesting the loculi which occur at the anterior end of bothria in *Echeneibothrium* and *Acanthobothrium;* no red pigment. My attention was called by Mr. Gudger to some minute oval forms from this same lot which proved to belong here. They were similar to minute specimens found in *Lagodon* and others; length 0.09, breadth 0.06 mm. These minute forms contained calcareous bodies of relatively large size in the parenchyma. July 15; large numbers, minute. July 16; immense members, length 0.06 when contracted, 0.12 when extended, heads relatively large, cases of constriction making pseudo-segments noted in this lot. July 17; very numerous, small. July 29; very numerous, 0.01 mm. in length. Aug. 4; few, comparatively large.

2. *Rhinebothrium* sp. [Fig. 75.]

Cysts with blastocysts containing larva which are identical with No. 4 under *Opsanus tau*, but do not occur in felted clusters so commonly as in that host.

July 7; few. July 9; 24. July 23, 25; several. Aug. 4; few. Aug. 6; a large number on and in the liver, others on viscera; as in the toad-fish, so in this case the blastocysts were much elongated at the posterior ends, which were felted together in clusters. No cases were found which demonstrated budding of blastocysts, although the manner in which the blastocysts are associated together would suggest that as a possible explanation of the frequent occurrence of clusters of this parasite. Aug. 20; several.

3. *Tetrarhynchus bisulcatus* Linton.

July 17; 1 scolex, encysted on viscera.

TREMATODES.

4. *Distomum* sp.

Aug. 12; 1; length 1.65 mm.; breadth 0.63 mm.; agrees with No. 4 under *Spheroides maculatus.*

5. *Distomum valde-inflatum* Stossich.

Aug. 12; 1; encapsuled on viscera.

PROTOZOA.

6. *Gregarines.*

July 17. The testis of a pipe-fish which was infested with what was taken to be a gregarine parasite was brought to my table by Mr. E. W. Gudger, who was working on the development of the pipe-fish. On account of the large amount of material to be looked over on this date, I was not able to give this much attention. Aug. 6; small, irregular gregarine-like forms observed in testis.

### **Menidia menidia,** *Silverside.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1902. | | |
| July 7 | 7 | Fish. |
| July 8 | 7 | Intestines filled with copepods and other minute entomostraca with a few foraminifera. |
| July 17 | 4 | Amphipods, young gastropods, copepods, spines of annelids. |
| July 19 | 2 | Same food as above with addition of shrimp eggs. |
| July 22 | 2 | Contents nearly completely digested; some vegetable débris. |
| July 23 | 4 | Material almost entirely digested; a few annelids. |
| August 1 | 3 | Nearly digested; small fragments of annelids. |
| August 7 | 5 | Food not noted. |
| August 11 | 1 | Intestine packed with megalops, small shrimp, copepods, and a few small gastropod shells. |

NEMATODES.

1. *Immature nematodes* (*Ascaris*).

Common type, diverticula to both intestine and œsophagus.

1902.—July 19; few. Aug. 7; few.

CESTODES.

2. *Scolex polymorphus* Rudolphi.

Aug. 1, minute forms seen in small piece of intestine which was being examined under the compound microscope for the food contents.

TREMATODES.

3. *Distomum monticellii* Linton.

Aug. 7; 1, voluminous intestine; no ova.

4. *Distomum* sp.

This form resembles that figured in Parasites of Fishes of the Woods Hole Region, figs. 357, 358. The body of this worm is densely clothed with exceedingly minute spines.

Dimensions, life, in millimeters: Length 0.94; diameter, anterior 0.07, middle 0.22, posterior end 0.12; diameter of oral sucker (not distinct) 0.04, of ventral sucker 0.09, of pharynx 0.03; ova 0.018 by 0.014.

Aug. 7; 1. The measurements of this specimen agree closely with the foregoing; the oral sucker, which was more plainly seen than in the specimen of July 7, measured 0.08 mm.; length 0.93; diameter 0.27; ventral sucker 0.11, pharynx 0.04; ova 0.025 by 0.018.

5. *Distomum pyriforme* Linton.

July 7; 2. July 8; 1. July 23; 1.

6. *Gasterostomum gracilescens* Rudolphi. [Fig. 236.]

See also under *Caranx*, *Menidia*, *Opsanus*, *Paralichthys*, *Pomatomus*, *Spheroides*, *Stolephorus*, and *Tylosurus*.

July 8; 1; length 0.75; greatest breadth 0.44; anterior sucker 0.2; mouth sucker 0.05. July 17; 12; small, oval, densely clothed with squarish spines; length 0.9, breadth 0.4; encapsuled, in some cases more than one in a capsule. July 23; few, small, not in good condition. Aug. 1; few. Aug. 7; several in yellowish cysts on viscera, small, oval. Aug. 11; few in cysts on viscera.

7. *Monostomum* sp.

This is the same species as No. 5 under *Fundulus majalis*. July 22; 3.

COPEPOD PARASITES.

8. *Ergasilus* sp., from gills.

Aug. 7; several; length, including egg masses, 1.5 mm.; length of egg mass 0.7 mm.

### **Mugil curema,** *White Mullet.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| August 3 | 1 | Mud consisting of vegetable débris with diatoms; no entozoa found. |

**Mugil cephalus**, *Common Mullet.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901 | | In general the contents of the alimentary canal consisted of vegetable débris reduced to a pulp, in which were immense numbers and many species of diatoms, with a considerable proportion of sand.<br>One fragment of a nemertean was found. Most of the fish examined in 1902 were small. |
| July 6 | 8 | |
| July 9 | 6 | |
| July 10 | [illegible] | |
| July 11 | 6 | |
| July 15 | 7 | |
| August 6 | 1 | |
| August 26 | 11 | |
| 1902. | | |
| July 16 | 7 | |
| July 17 | 3 | |
| July 19 | [illegible] | |
| July 21 | 1 | |
| July 22 | 3 | |
| July 31 | 2 | |
| August 4 | 2 | |
| August 19 | 1 | |

COPEPODS.

1. *Anchorella* sp.

Form with linear, tapering neck, postero-lateral egg sacks, and thoracic appendages modified into a cylindrical organ which slips over a gill filament of its host. [Figs. 57, 58.]

Dimensions, in millimeters, life: Length 6; breadth of posterior portion through egg sacks 2; length of neck 3.5; diameter of neck near base 0.7, at anterior end 0.2.

Cuticle transparent, colorless, glistening. General color white, faintly pinkish or flesh color by reflected light; alimentary canal black, making a broad black band with irregular outline, most conspicuous in the neck. The cylindrical organ of attachment was 1.6 mm. in length. It consists of two rings placed end to end, each ring having a distinct annulation at its middle. Rudimentary maxillæ occur at the anterior end. These were in constant, quick motion. The body and neck also kept up convulsive movements, which, in an unmutilated specimen, continued for a long time.

1901.—July 10; 2. July 11; 6. July 15; few. July 15; 6. The eggs in this lot were segmenting. Aug. 26; 1.

1902.—July 21; 3. July 31; 4. Aug. 4; 2. Aug. 19; 1.

2. *Copepods.* Small, white, from gills.

1901.—July 11; 4. July 15; few. Aug. 26; 1.

3. *Ergasilus* sp.

1901.—July 11; 1; from gills.

**Sphyræna borealis**, *Northern Barracuda.*

| Date | Number of fish examined. | Food notes. |
|---|---|---|
| 1902. | | |
| July 17 | 2 (small) | Fragments of small shrimp; no entozoa. |
| July 19 | do | Fish. |

TREMATODES.

1. *Distomum* sp. [Fig. 211.]

1902.—July 19; 1. This specimen was found when a small piece of the intestine was being examined under the compound microscope. Dimensions in millimeters: Length 0.24; diameter, anterior 0.028, at ventral sucker 0.057, maximum 0.072, near posterior end 0.021; diameter of anterior sucker 0.018, ventral sucker 0.036.

**Upeneus maculatus**, *Red Goat-fish.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1902. | | |
| July 19 | 1 (75 mm.) | Alimentary canal empty. |

### PARASITIC COPEPODS.

1. *Lernæonema* sp.

Two on gill cover and 1 in flesh of abdomen near anal opening.

Body filled with red fluid which circulates by means of somewhat irregular pulsations. It was observed to grow gradually slower and slower, then pause. After a short time it would resume and go at the rate of from 100 to 108 beats a minute.

Pulsations were also noted at the arch of the neck next to the antler-like branches of the head. The head was also filled with red fluid; neck and branches yellowish by transmitted light. Length, head and neck 6 mm.; body 6 mm.; egg chains 8.5 mm. Considerable irritation is produced by this parasite. The tissues where the head and neck were buried were more or less congested and inflamed.

These together with other copepod parasites collected by me at Beaufort have been turned over to Prof. C. B. Wilson.

## **Scomberomorus maculatus**, *Spanish Mackerel.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901.<br>August 30 | 1 | Contents of alimentary canal almost completely digested There were recognized only a few crystalline lenses and small bones of fish and fragments of small crustaceans. |

The viscera of a fish from the market, reported to me to be a mackerel, probably belong here. Examined on July 8, 1901. Fragments of fish in alimentary canal.

### CESTODES.

1. *Rhynchobothrium* sp.

One. The larva has some points of resemblance in essentials with the specimens from *Elops saurus*, but is smaller, and the part behind the contractile bulbs is slender.

Dimensions of living specimens in millimeters: Length 3.43; length of bothrium 0.63, of contractile bulbs 0.35, of part behind bulbs 0.63. A comparison of the preserved material shows that the contractile bulbs have approximately the same length. The probocides in this specimen were only partly evaginated, but so far as could be made out they are in close agreement with the species from *Elops* (figs. 99, 100).

The same species is represented by No. 3 under *Scomberomorus regalis.*

2. *Tetrarhynchus bisulcatus* Linton.

July 8; 1 scolex, on viscera, very active.

3. *Synbothrium filicolle* Linton.

July 8, few, on viscera. Aug. 1; 1; similar to No. 6 under *Scomberomorus regalis.*

### TREMATODES.

4. *Gasterostomum baculum* sp. nov. [Figs. 233, 244.]

1901.—Aug. 30, 6. This is the species recorded from this host before.

See No. 8 (*Gasterostomum* sp.) under *S. maculatus*, Bulletin U. S. Fish Commission for 1899, p. 447. Dimensions, in millimeters, life: Length 2; maximum diameter 0.4; anterior sucker, length 0.17, breadth 0.19; ventral sucker, length 0.069, breadth 0.065; ovum 0.021 by 0.014.

## **Scomberomorus regalis**, *Cero.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901.<br>August 23 | 1 | Length of specimen 3 feet, weight 15 pounds. It did not quite agree with the description of this species given in Jordan & Gilbert's Fishes of North America, but was nearest that form. The contents of the alimentary canal were completely digested. No distinguishable fragments were found, even when looked for with the aid of the microscope. |

NEMATODES.

1. *Immature nematodes* (*Ascaris*). On viscera.

Type with short diverticulum of intestine and corrugated post-anal region.

CESTODES.

2. *Cestode blastocysts.*

Two from outside of viscera, vase-shaped.

3. *Rhynchobothrium* sp.

Two larvæ from cysts on viscera; neck elongated; bothria emarginate with elevated border; proboscides not seen everted, but long; sheaths in close spiral when neck is at rest. Dimensions in millimeters, specimen mounted in glycerine: Length of bothrium 0.36, breadth 0.42; diameter of neck 0.31, length of neck 2.4; length of part behind bulbs 0.68; length of longest hooks 0.021.

See No. 3 under *Hexanematichthys.*

4. *Otobothrium crenacolle* Linton. [Fig. 111.]

Enormous numbers of small cysts in walls of stomach and intestine, for the most part on the submucosa. Some of the cysts were amber colored and filled with waxy, degenerate tissue; others contained blastocysts which contained no identifiable embryo, while others contained larvæ which could be identified through the wall of the enclosing blastocyst. One of the latter in life and under slight pressure had the following dimensions, in millimeters: Length of blastocyst 1, diameter 0.8; length of larva 0.32, of bothrium 0.16, breadth of bothrium 0.12. One amber-colored, oval, thick-walled cyst was 1.54 by 1.09, the blastocyst 0.52 by 0.28; length of larva 0.28.

5. *Tetrarhynchus bisulcatus* Linton.

A few scolices were found in the material collected from this fish. It is likely that many of the cysts in the stomach and intestinal walls belong to this species. The hooks on the proboscides are shorter than is the rule in this species, but the number, shape, and arrangement are in agreement with the usual type. Diameter of proboscis, excluding hooks, 0.034, including hooks 0.044; length of hooks 0.01 mm.

6. *Synbothrium filicolle* Linton.

Numerous on viscera; type with small, slender, recurved hooks; elongated blastocysts in brownish cysts.

TREMATODES.

7. *Distomum monticellii* Linton.

One. Genital organs very indistinct. The stained specimen has a faint indication of lobed organs, apparently the vitellaria near the posterior end. Measurements of living specimen under slight pressure, in millimeters: Length 2; maximum breadth 0.52; oral sucker, length 0.09, breadth 0.011; pharynx, length 0.05, breadth 0.06; ventral sucker, length 0.26, breadth 0.27; ovum 0.017 by 0.010 in the two principal diameters.

8. *Gasterostomum arcuatum* Linton. [Fig. 235.]

Fifteen. These specimens resemble this species, although no spines were seen. They were not in good condition when found. At the anterior end there is a knob-like projection of the anterior sucker; vitellaria agree in number and position, but are smaller. Dimensions of specimen in sea-water, pressure of cover glass, in millimeters: Length 4.2; diameter 0.26, of anterior projection 0.11; length of cirrus pouch 0.63; ovum 0.020 by 0.014. Diameter of pharynx in another specimen 0.05.

## **Seriola lalandi**, *Amber Jack.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1902.<br>August 23 | 1 | Alimentary canal empty. |

This specimen was taken on Aug. 21 by the Fisheries steamer *Fish Hawk*, about 28 miles off Cape Lookout, North Carolina. The viscera were placed in formalin and brought into the laboratory on the 22d. The material was looked over on the 23d.

### NEMATODES.

1. *Ascaris incurva* Rudolphi.

Four adult females and 2 smaller, which appear to be young; slender, fusiform; length 16–20 mm. Ova, some nearly spherical, about 0.05 mm. in diameter; others short oval 0.06 by 0.04.

So far as these specimens have been examined they agree with this species, although much smaller than specimens from the sword-fish.

### TREMATODES.

2. *Distomum monticellii* Linton.

Few, small, immature.

3. *Distomum hispidum* Abilgaard.

Fifty; with oral spines and stout spines on the neck. There is considerable variety of shape and size in this lot, but so far as studied they appear to belong to the same species.

4. *Distomum* sp. [Figs. 206, 207.]

One, length 5 mm., breadth 0.5 mm. This specimen was at first a very puzzling one. On account of the apparent segmentation of the posterior part it was recorded in the notes made at the time of collecting as the fragment of a cestode. The posterior end is apparently four-jointed, the anterior end is much crumpled and folded together. The specimen had been killed with formalin before it was examined. When stained and sectioned it is seen to be not a cestode but a distome. The close approach to segmentation of the body is evident also in the sections. The general arrangement of the reproductive organs is shown in the diagrammatic sketch. The vitellaria are abundant, posterior and peripheral, extending as far forward as the seminal vesicle; testes two, on median line, following each other much as in *D. tenue*. The ovary is situated a short distance in front of the anterior testis. I was able to find only one intestine in the sections. It is persistent to the posterior end. The ova, which are numerous, are massed between the ovary and the seminal vesicle, 0.06 by 0.03 mm., in the two principal diameters. Very little can be made out of the section of the crumpled anterior part more than the presence of at least one sucker.

5. *Gasterostomum gorgon* sp. nov. [Figs. 240–242.]

Sketches and description based on specimens which had been killed in formalin.

Small, rather plump and somewhat fusiform worms, differing from other species of this genus mentioned in these notes by having a cylindrical neck and the anterior sucker surrounded by a crown of about eighteen tentacles. In most cases the anterior end was inverted, when the worms have the general appearance of such gasterostoma as those found in the gar and other fish. The appendages are not hooks, although somewhat rigid, and they doubtless function as a kind of grappling organ to enable the worm to maintain a lodgment in its host. There is a dense covering of minute spines on the body. These spines are very short, flat, and rounded when seen on the flat surface, although appearing slender when seen in profile.

The following points in the anatomy were made out: The characteristic cirrus pouch of the genus lay at the posterior end, and equaled nearly one-third the length of the body; the small, globular ovary was situated at its anterior end. The two testes lay on the dorsal side of the anterior third of the cirrus pouch, diagonal and close together. The intestine was ellipsoidal, elongate in a ventro-lateral view and immediately in front of the ovary. The globular vitellaria are dorsal and anterior to the intestine. The number was not definitely made out. Twenty-five were counted in lateral view.

The position assumed by the worms in formalin is arcuate, as shown in the sketches. In the inverted specimens the anterior end is more or less truncate in outline. The ova, which occupy the greater part of the interior of the body, are yellow and conical.

Dimensions of one in formalin: Length 1.65 mm; diameter of body 0.36 mm.; of neck 0.21 mm.; of circle of tentacles 0.36 mm.; ova 0.022 by 0.014 mm.

6. *Gasterostomum* sp.

Few. These are very small and are a different species from No. 5. The anterior sucker is relatively smaller, and there are no tentacular processes; ova elliptical.

### COPEPOD PARASITES.

7. *Copepod parasites.*

Two; from gills.

### **Caranx hippos**, *Crevallé.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| July 31 | 1 (small) | Small crustacea. No entozoa found. |
| August 15 | 1 | Several otoliths of fish found in alimentary canal. |
| August 17 | 12 | Nothing found in alimentary canals that could be identified except a few otoliths of fish. |
| 1902. | | |
| August 11 | 1 (small) | Food not noted. |

NEMATODES.

1. *Immature nematodes* (*Ascaris* sp.).

1901.—Aug. 15, 2. This is the type characterized in these notes as having a short diverticulum of the intestine and transversely corrugated post-anal region. Aug. 17, few.

CESTODES.

2. *Tetrarhynchus bisulcatus*, Linton.

1901.—Aug. 15, from cyst in stomach wall. The hooks on the proboscis were rather smaller than the dimensions which I have given for this species. In other particulars the agreement is perfect.

TREMATODES.

3. *Distomum appendiculatum* Rudolphi.

1902.—Aug. 11, 2; small; no ova; in poor condition.

4. *Distomum tenue* Linton.

1901.—Aug. 17, 1. This agrees closely with the variety *tenuissime*. Dimensions, life, in millimeters: Length 6.3; diameter 0.56, of oral sucker 0.22, of pharynx 0.12, of ventral sucker 0.26; ovum 0.068 and 0.043 in the two principal diameters. The arrangement and proportions of the genitalia are in close agreement with this species. The ova, however, are considerably smaller. A few flat, rounded scales remained about the middle of the length on the dorsal side; pharynx remote from the oral sucker; esophagus short, specimen not in good condition.

5. *Gasterostomum arcuatum* Linton.

1901.—Aug. 17, 3; in poor condition, referred with some doubt to this species. Length about 2 mm.; ovum, length 0.020, breadth 0.013; another 0.024 and 0.017 in the two principal diameters.

6. *Gasterostomum gracilescens* Rudolphi. [Figs. 230–232.]

1901.—Aug. 15, 1; small, immature, fusiform, flask-shaped when compressed. Dimensions under pressure, in millimeters: Length 1.17; diameter, anterior 0.21, middle 0.54, posterior 0.11; pharynx, length 0.11, breadth 0.08. Body covered with very minute, squarish spines.

1902.—Aug. 11, 1.

See under *Menidia menidia* and *Tylosurus marinus*, etc.

### **Selene vomer**, *Moon-fish.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1902. | | |
| July 31 | 3 (small) | Shrimp and other small crustacea. |
| August 18 | 1 (small) | Shrimp, gastropods, lamellibranchs, sand; no entozoa. |

CESTODES.

1. *Tetrarhynchus bisulcatus* Linton.

July 31; 1 scolex from cyst in stomach wall.

### Trachinotus carolinus, *Pompano.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| August 28 | 1 | Alimentary canal nearly empty, the scanty contents almost completely digested. There were recognized only a few bits of wood and the spine of a sea-urchin (*Toxopneustes*). |
| August 30 | 3 | A large number of broken lamellibranch shells. |
| 1902. | | |
| July 18 | 7 (12 to 20 mm.) | Diatoms and vegetable débris. |
| July 19 | 1 (75 mm.) | Fragments of small crustacea. |
| July 21 | 1 (50 mm.) | *Solenomya.* |
| July 22 | 1 (small) | Fragments of small crustacea; no entozoa. |
| July 23 | 8 (small) | Large number of broken lamellibranch shells, some copepods and small crustacea. |
| July 31 | 2 (small) | Fish |
| August 15 | 12 (small) | Small amphipods and lamellibranchs. |

PROTOZOA.

1. *Myxobolis* (*Henneguya*) sp. [Fig. 55.]

1901.—Aug. 30, cysts, 1 mm. and less in diameter, on mucous membrane of stomach and intestine. Color of cysts dead white. Spores: Length (not including caudal spine) 0.014 mm., breadth 0.007 mm.; length of caudal spine about equal to that of the spore proper.

These Sporozoa agree with those found in the drum (*Sciænops ocellatus*) and sheepshead (*Archosargus probatocephalus*).

NEMATODES.

2. *Immature nematodes* (*Ascaris*).

1901.—Aug. 28, few; type with slender diverticulum from basal bulb of œsophagus and short anterior diverticulum of intestine. Aug. 30, numerous, from alimentary canal; œsophagus long and slender; diverticula as in those of preceding date.

1902.—Aug. 15, several.

CESTODES.

3. *Scolex polymorphus* Rudolphi.

1902.—July 19 and 21, Aug. 15, few, small.

4. *Rhynchobothrium* sp.

1902.—Aug. 15, commonly recurring form—small larva with relatively large hooks from small oval cysts on viscera.

TREMATODES.

5. *Distomum monticellii* Linton.

1902.—Aug. 15, few; small, immature, with orange-colored spherical bodies in the excretory vessels.

6. *Distomum vitellosum* Linton.

1902.—July 19, 1, small, immature. July 23, 1, distended and rigid when first seen. It had lain in sea water about twelve hours.

7. *Distomum valde-inflatum* Stossich.

1902.—Aug. 15, few, in globular cysts.

8. *Distomum pectinatum* sp. nov.

See No. 15, under *Bairdiella chrysura.* July 19, 4. July 31, 3, small.

On July 18 clusters of distome eggs were found in the intestine of this host, about 100 ova in all, each 0.025 by 0.014.

9. *Distomum* sp. [Fig. 204.]

1901.—Aug. 28, 1. This is a very remarkable form, if the specimen is entire. Following are my notes made at the time of collecting:

Ventral sucker near posterior end, as if the neck and body in a form like the appendiculate distome *D. tornatum* had been interchanged. Surface slightly nodular, length 5.5 mm.; distance of center of ventral sucker from anterior end 4 mm., from posterior end 1.5 mm.

Other dimensions, life, in millimeters: Breadth at middle of neck 0.88, behind ventral sucker 0.61; oral sucker, length 0.4, breadth 0.5; pharynx, length 0.21, breadth 0.21; ventral sucker, length and breadth each 1. Posterior end tapering and truncate.

Specimen too opaque to show anatomy. It looked as if it had been broken behind the ventral sucker, but when examined with the aid of the microscope there was no indication of any break. Subsequent examination of longitudinal sections revealed the following anatomical features: The pharynx is adjacent to the posterior edge of the oral sucker. There is no œsophagus. The intestinal rami extend to the posterior end of the body. The ovary is lobed and lies at the extreme posterior end of the body, where it is immediately preceded by the testes, which are two in number, median, and close together. The uterus is voluminous and lies for the most of its length in front of the ventral sucker. The genital aperture is about median and close behind the pharynx. The cirrus is surrounded by a rather large prostate and the vas deferens lies in many folds posterior to it, but not inclosed in the cirrus pouch. The vitellaria appear as clustered granules, mainly peripheral from the testes to near the anterior end. Ova numerous, with thin shells 0.027 by 0.014 mm. in the two principal diameters.

10. *Monostomum* sp. [Figs. 226–229.]

1901.—Aug. 28, numerous small ovoid or elongated forms. Most of these worms were elongated anteriorly, very delicate and fragile. When highly magnified the body is seen to be crossed by exceedingly minute transverse lines, becoming a little coarser toward the posterior, where the outline is finely serrate. . Posterior half of the body filled with eggs.

Dimensions of living uncontracted specimen, in millimeters: Length, 1.5; greatest breadth, 0.45; diameter of oral sucker, 0.075; of pharynx, 0.034; ova, 0.028 and 0.017 in the two principal diameters. Each ovum bears a filament of about the same length as the body of the ovum. A contracted specimen measuring 0.87 mm. in length yielded about the same measurements of other parts as the uncontracted specimen—i. e., oral sucker, 0.09; pharynx, length, 0.048; breadth, 0.034. The difference in length is made mainly by the contraction or elongation of the neck.

1901.—Aug. 30, 1.

11. *Aspidogaster ringens* sp. nov. (See No. 24, under *Micropogon undulatus.*) [Figs. 243–249.]

1901.—Aug. 28, many. There is a considerable variety of coloration in these worms. Some are orange, darker on back, pinkish below, pale posteriorly. Ventral sucker with pale border and pink center in some; in others pale throughout; in others orange. General color effect reddish-brown.

The ventral sucker is thick and fleshy and has many loculi. The head appeared to be expanded into four short leaf-like lobes. Dimensions of a specimen lying in sea water, somewhat contracted: Length, 2 mm.; breadth, 0.8 mm.; thickness, 0.7 mm. The favorite attitude seems to be with the back convex and the ventral surface concave. Some are doubled on themselves ventrally. None were seen in active motion.

1901.—Aug. 30, 19. A mounted specimen from this lot has two lobes on the ventral border of the mouth and three on the dorsal, as shown in figures of specimens from the croaker.

**Pomatomus saltatrix**, *Blue-fish.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| July 9 | 4 | Young fish in alimentary canals. |
| July 10 | 6 | Fragments of small fish. |
| July 18 | 1 | Alimentary canal empty. |
| July 23 | 1 | Fragments of fish. |
| July 29 | 1 | Alimentary canal empty. |
| July 30 | 3 | Fish. |
| August 3 | 1 | Do. |
| August 24 | 1 | Food completely digested. |
| August 27 | 7 | Pin-fish and shrimp. |
| August 28 | 1 | Fish and shrimp. |
| August 30 | 2 | Shrimp. |
| August 31 | 3 | Fish and shrimp. |
| 1902. | | |
| July 16 | 1 (60 mm.) | Numerous exceedingly minute spines in chyle; no entozoa. |
| July 17 | 6 (small) | Fish. |
| July 21 | 8 (small) | Fish; no entozoa. |
| July 22 | 2 (small) | Fish, amphipods and other small crustacea. |
| July 23 | do | Fish, small gastropod shells; no entozoa. |
| July 25 | 6 (small) | Fish and small annelids. |
| July 28 | 1 (small) | Not recorded. |
| July 29 | 2 (small) | Fish. |
| July 31 | 1 (small) | Fish, shrimp. |
| August 4 | 2 (small) | Fish. |
| August 8 | 5 (small) | Fish, shrimp, spines of annelids. |
| August 11 | 1 (small) | Fish, shrimp. |
| August 12 | do | Shrimp. |
| August 16 | 3 (small) | Fish, shrimp, bryozoa. |
| August 20 | 1 (small) | Fragments of small crustacea. |
| August 22 | 1 (small) | Fish. |

All the blue-fish examined at Beaufort were small, but few of them reaching a length of more than 8 inches.

### ACANTHOCEPHALA.

1. *Echinorhynchus pristis* Rudolphi.

1901.—Aug. 28, 1 female.

### NEMATODES.

2. *Immature nematodes* (*Ascaris* sp.). [Fig. 34.]

1901.—Aug. 31, numerous, clustered cysts on viscera. Type with long diverticulum of œsophagus and short diverticulum of intestine—the most common form. Larger specimens with dark-brown intestine. Some of the cysts filled with brown, waxy secretion.

1902.—Aug. 11, cyst on viscera filled with fine granular material in which the very small worms were embedded.

3. *Immature nematodes* (*Ascaris* sp.).

1901.—Aug. 27, 28, several on each date. This form differs from No. 2 in having no diverticulum of the œsophagus, and the postanal region corrugated. Same form noted on other occasions in other hosts, but not of such frequent occurrence as the preceding. Same type as shown in fig. 31.

4. *Ichthyonema globiceps* Rudolphi.

1902.—July 25, fragments; neither extremity was seen; intestine dark-brown. July 28, many fragments. Aug. 4, several fragments; filled with the characteristic young, anterior end blunt, posterior attenuated, length about 0.5 mm.; diameter 0.01 mm. These fragments were in poor condition. They were from the alimentary canal where they had evidently been affected by the digestive juices of the fish. Aug. 8, 2 females, 212 and 20 mm., respectively. Longer specimen with fully developed young in the uterus which occupied the greater part of the body. The smaller specimen with eggs in the uterus. These worms came from the stomach, color reddish, intestine, as in all, dark-brown. Aug. 11, fragments. Aug. 22, numerous fragments. The broken condition was doubtless due to the fact that the intestines of the fish had been cut into small pieces to allow any small distomes that might be in them to creep out into the water. Aug. 26, fragments, one blood-red.

### CESTODES.

5. *Scolex polymorphus* Rudolphi.

1901.—July 23, few; very small, in alimentary canal. July 29; few, small; no red pigment observed; rudiment of costa on each bothrium; a strong, terminal, muscular sucker about equaling a bothrium in size.

1902.—July 17, 25, few. July 31; many, small. Aug. 4, 20; few, small.

6. *Larval Dibothrium* (?).

1901.—July 30, 2 flask-shaped larvæ from serous covering of viscera. The anterior end of one of them was everted with the aid of needle points, when it was seen to possess two structures which appeared to be the rudiments of bothria; length about 2 mm.

7. *Cestode larva.*

I here record a peculiar blastocyst collected on July 18, 1901, from the outside of the viscera; length 12 mm., breadth 2 mm., the dimensions, however, varying with states of contraction. [Fig. 81.]

The minute, spine-like bristles, characteristic of cestode larvæ and blastocysts, suggested by their shape the gland hairs of certain plants, being slightly knobbed at the ends. This feature was observed only at the anterior end of the specimen.

8. *Rhynchobothrium speciosum* Linton.

1901.—July 9, 1, encysted on viscera. Aug. 28; a specimen with rather long and slender neck, which was referred at the time of collecting to this species, but with some doubt.

9. *Rhynchobothrium* sp.

Hooks suggest *R. plicatum* sp. nov.

1901.—Aug. 30, few, from oval cysts on viscera. Aug. 31; 1.

1902.—July 22, few. July 31; 1

Type with long neck and small but not minute hooks.

10. *Otobothrium crenacolle* Linton.

1901.—July 30, encysted in stomach wall. Aug. 28; numerous, encysted in stomach wall.

11. *Tetrarhynchus bisulcatus* Linton.

1901.—July 10, 30; Aug. 31; cysts in stomach wall; few on each occasion.

12. *Synbothrium filicolle* Linton.

1901.—Aug. 30, 1.

1902.—Aug. 22, 1, from cysts on viscera.

13. *Synbothrium* sp.

See introduction, and No. 10 under *Cynoscion regalis.*

1901.—Aug. 28, 3.

1902.—Aug. 20, 1, from cysts on viscera.

### TREMATODES.

14. *Distomum monticellii* Linton (?).

Appendiculate distomes which were found in this host on the following dates were thought at the time of collecting to represent three different species.

1901.—Aug. 24, 1. Apparently identical with No. 9 under *Lagodon rhomboides.* Aug. 28; 6; 5 of these not in good condition. One recorded in notes made at time of collecting as a distinct species proves to be an immature appendiculate distome. Dimension of specimen in millimeters, slightly compressed, in glycerin: Length 2; maximum breadth 0.9; diameter of oral sucker 0.28; of pharynx 0.18; of ventral sucker 0.53. Intestinal rami voluminous; reproductive organs rudimentary. Aug. 31; 1. Dimensions, life, compressed, in millimeters: Length 5; breadth 1.5; diameter of oral sucker 0.34; of pharynx 0.21; of ventral sucker 0.82; no ova.

15. *Distomum vitellosum* Linton.

1901.—July 30, 2, small.

1902.—Aug. 16, 2.

16. *Distomum dentatum* Linton.

1901.—Aug. 31, 1. The specimen was in poor condition. It appears to be an individual which has lost the oral spines.

17. *Distomum tenue* Linton.

1902.—July 17, 1, not in good condition. Aug. 8; 1, in poor condition; no spines certainly made out, but specimen looks as if it had been armed with spines.

18. *Gasterostomum gracilescens* Rudolphi.

1902.—July 17, 1.

See under *Menidia*, *Tylosurus marinus*, etc.

19. *Microcotyle* sp. [Figs. 147–150.]

1902.—Aug. 8, 1, probably from gills; fragment, the posterior sucker-bearing portion missing. Figs. 147 and 148 were sketched from this specimen. The cirrus hooks formed an elongated cluster and are shown diagrammatically in fig. 148. Dimensions, life, in millimeters: Length 1.85; breadth at anterior end 0.12; greatest breadth 0.42; length of cirrus hooks 0.025. The specimen was very fragile. It was broken while it was being examined, and destroyed in an attempt to mount the fragments permanently. Aug. 16; 2, from gills. Aug. 22; 1. These specimens were complete and belong to this genus.

A mounted specimen has the following dimensions in millimeters: Length of body proper 1.20; of posterior sucker-bearing portion 1.12; diameter through anterior suckers 0.10; greatest diameter 0.37; diameter of posterior sucker-bearing part 0.18; suckers at anterior end, length 0.051, breadth 0.039; pharynx, length 0.42, breadth 0.036; posterior suckers number about 50 pairs, each sucker 0.042 by 0.021, the longer diameter transverse to axis of body; length of cirrus hooks about 0.015. The cluster of hooks on the cirrus is somewhat triangular, and each hook seems to be two-forked at the base. [Fig. 150.] The posterior suckers are provided with a chitinous framework, which is imperfectly shown in fig. 149.

### PARASITIC COPEPODS.

20. *Lernanthropus* sp. From gills.

1901.—July 10, 3, from gills. While I have not undertaken to identify the parasitic copepods, I here record an unusual form. The most striking feature was the possession of a pair of forked leaf-like appendages. These appendages were flexible and were frequently bent dorsally by a convulsive movement. The inner ramus of each appendage was the more active of the two and kept up a rhythmic movement which appeared to be directly concerned with the circulation of the blood. At each such movement the blood was driven along the marginal vessel toward the body, at the same time the blood left the marginal vessel of the outer ramus. As soon as the convulsive contraction was over the appendage relaxed by its own elasticity and the blood returned to its vessels. The general color effect is dark reddish-brown. The blood is red. The appendages made out are: 1, a pair of small antennæ; 2, a pair of hooked mandibles; 3, two pairs of maxillæ; 4, a pair of appendages on the thorax which terminate in horseshoe-shaped suckers; 5, forked appendages at posterior end which function as gills. The tail is forked at the tip with two brown chitinous sucking-disks. Egg sacs 2, cylindrical, dark brown, protruding posteriorly, nearly equaling length of body.

1902.—Aug. 8, 1, female, with elongated pinkish egg-chains. Aug. 12; 1. Aug. 16; 2. Aug. 22; 14. Aug. 26; several, males and females. These have been turned over to Prof. C. B. Wilson.

### **Rachycentron canadus,** *Cobia*, "*Cabio*" (Beaufort).

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| August 1 | 1 | Contents of alimentary canal completely digested, only yellow and green mucus present. |
| August 3 | 2 | Fish, crabs, and shrimp. |
| August 8 | 2 | Fish, shrimp, and crabs (spider crabs and others). |
| August 12 | 1 | Fish. |
| 1902. | | |
| August 8 | 1 (150 mm.) | Fish, shrimp, and annelid (*Arenicola*). |
| August 14 | do | Fish. |

All the fish examined in 1901 small, 16 to 18 inches in length.

### ACANTHOCEPHALA.

1. *Echinorhynchus sagittifer* Linton. [Figs. 1–7.]

1901.—Aug. 3, 3, adult, in intestine. This is the first find of the adult of this species. Immature specimens from the body cavity of many different hosts have been found, and upon such material the species was based.

When these adult specimens were first seen they were collapsed, flattened, and much crumpled, except at the posterior end, which for about 5 mm. was not transversely wrinkled, and, on account of its shape, suggested the head of a *Dibothrium.* Indeed, the worm at first sight might very easily be mistaken for a cestode. The resemblance is heightened by the shelf-like projections with dentigerous edges, which recur at rather regular intervals on the anterior half of the body, and of which 23 were counted in one individual, the last one, however, being rudimentary. These projections give to the worm a decidedly segmented appearance. The anterior 4 are somewhat crowded.

A specimen placed in fresh water plumped up after the manner of most of the *Echinorhynchi* when so treated, and afterwards transferred to killing fluid, measured 70 mm. in length. This was a female; another female measured 40 mm. and a male 23 mm. in length.

1901.—Aug. 8, 1 young and 5 adults found in the pyloric cæca.

Details of the anatomy of a male are shown in figs. 1–4.

### NEMATODES.

2. *Ascaris inquies* Linton.

1901.—Aug. 3, 2, young. Aug. 8, 2 large, 6 small. Aug. 12, 3; 1 of them a male with very long spicules.

### CESTODES.

3. *Scolex polymorphus* Rudolphi.

1902.—Aug. 14, 1, small.

4. *Rhinebothrium*, near *R. flexile.*

1901.—Aug. 3, many, in blastocysts. These were found in the alimentary canal. It is not at all likely that this fish is the final host. This larval *Rhinebothrium* is identical with the one found in the toad-fish.

5. *Cysts.*

1901.—Aug. 1, a few cysts found in the stomach wall; contained white, granular material, but no entozoa.

6. *Rhynchobothrium* sp.

This appears to be the kind referred to in this paper as small with relatively long hooks. (See introduction.)

1902.—Aug. 8, several small scolices, with blastocysts attached. Dimensions, life, in millimeters: Length 0.8; head, length 0.14, breadth 0.22; neck, length 0.40, breadth 0.15; length of body back of bulbs 0.38; diameter of proboscis, excluding hooks, 0.018; length of longest hooks 0.014.

7. *Tetrarhynchus bisulcatus* Linton.

1902.—Aug. 8, few, from cysts in stomach wall.

### TREMATODES.

8. *Distomum monticellii* Linton. [Fig. 154.]

1901.—Aug. 1, 3, very active, the neck especially so, being filiform when fully extended and capable of speedily shortening until the oral and ventral suckers almost touch each other; color pale red. Length, when compressed, 5 mm.; ova 0.023 by 0.017 mm. in the two principal diameters. Aug. 3, 2; length 2 mm.; diameter of oral sucker 0.14 mm., pharynx 0.07 mm., ventral sucker 0.35 mm.; ova as in foregoing.

1902.—Aug. 8, 6, length 4.2 mm.; 1 smaller, 1.2 mm.

9. *Distomum imparispine*, sp. nov. [Figs. 189–194.]

Body elongate, of nearly uniform breadth throughout, narrowing somewhat at the neck and for a short distance behind ventral sucker. Neck and anterior part of body armed with spines, which are sagittate on the ventral side of the neck, slender and curved on the lateral margins of the neck, somewhat irregular on dorsal side of body, and disappear altogether about the posterior third. Mouth surrounded by stout but unequal spines, which are 33 in number in the sketch (fig. 190); 34 were counted in the specimen. The number is probably variable. Ventral sucker larger than oral, its posterior border situated at about the anterior fourth of the entire length of the worm; pharynx large, long pyriform, remote from the mouth. Testes two, large, near posterior end, on median line, end to end, the posterior one the larger; cirrus-pouch long, behind ventral sucker; genital aperture not distinctly seen, but evidently on or near median line, close in front of ventral sucker. Ovary near front end of anterior testis; uterus in front of ovary, its folds mainly between ovary and cirrus-pouch; ova moderately numerous and relatively large; vitellaria diffuse, abundant posteriorly, and extending laterally to a point near base of cirrus-pouch.

1901.—Aug. 1, 3.

Dimensions, life, ventral view, in millimeters: Length 9; diameter of head 0.65; of neck, narrowest part, 0.5; transverse diameter of oral sucker a little difficult to make out on account of the spines but about 0.56; breadth of ventral sucker 0.7, length of same 0.9; diameter of globular ovary 0.3; length of anterior testis 0.84; of posterior testis 1.16; breadth of each 0.56; ova 0.07 by 0.04 in the two principal diameters; length of larger oral spines 0.15. Pharynx, same specimen in glycerin, length 0.45; breadth 0.21. Number of oral spines 34.

10. *Distomum* sp. [Figs. 171, 172.]

1901.—Aug. 3, 1. Dimensions, life, lateral view, in millimeters: Length 1; longitudinal diameter of oral sucker 0.08, of pharynx 0.05, of ventral sucker 0.17; ova much smaller at one end than the other, almost pointed-oval, 0.04 by 0.02 in the two principal diameters.

1902.—Aug. 8, 1.

See No. 17 under *Paralichthys albiguttus.*

11. *Distomum pudens* Linton.

1902.—Aug. 8, 1, in poor condition and crushed by accident under cover glass. Dimensions, life, in millimeters: Length 1.3; diameter of oral sucker 0.12, of pharynx 0.10, of ventral sucker 0.11; distance of pharynx from oral sucker 0.27, from ventral sucker 0.04; neck conical.

12. *Distomum dentatum* Linton.

1902.—Aug. 8, 1, small, immature; length 1.2 mm.

13. *Distomum valde-inflatum* Stossich.

1902.—Aug. 8, 1, in cyst.

### **Coryphæna hippurus,** *Common Dolphin.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1902.<br>August 1 | 1 | Fish, among which a small lizard fish and silverside were recognized. |

This fish was sent to the laboratory by Mr. Charles S. Wallace, of Morehead City, N. C.

ACANTHOCEPHALA.

1. *Echinorhynchus sagittifer* Linton.

One, immature; encapsuled on the viscera.

NEMATODES.

2. *Ascaris increscens* Molin.

One, jaws short and broad; post-anal region very short.

3. *Ascaris* sp.

Fragments; one of them the posterior end of a male, with long conical post-anal region. Three pre-anal and four post-anal papillæ were seen in side view.

4. *Immature nematode* (*Ascaris*).

Type with elongated basal part of œsophagus and corrugated post-anal region.

5. *Ichthyonema* sp.

Fragments of female. Ova from one 0.036 by 0.018 mm., from another 0.032 by 0.016 mm. in the two principal diameters.

CESTODES.

6. *Rhynchobothrium speciosum* Linton.

One larva from cyst in stomach wall; another blastocyst without distinguishable larva may belong to a different species.

7. *Otobothrium crenacolle* Linton.

Very numerous, encysted in submucous coat of stomach.

8. *Tetrarhynchus bicolor* Bartels.

Two from cyst in stomach wall. The cyst was globular and of a greenish hue.

TREMATODES.

9. *Distomum tornatum* Rudolphi.

Very numerous, for the most part in the stomach; 671 were collected. There was great variation in size, one of the smallest measuring 3 mm. and one of the largest 12 mm. in length. The fish had been dead for about thirty-six hours, during the greater part of which time it had been kept on ice. The worms were dead, but were apparently in good condition. The color was white except where the folds of the uterus lay, where the color varied from pale yellow to orange. The cirrus was seen extruded in several cases and was noted to be distinctly nodular.

10. *Distomum monticellii* Linton.

Four; length 2.5 mm.

11. *Distomum tenue* Linton.

Forty-two; elongated, slender, white. These are without oral spines and the bodies of most are smooth. In a few cases spines were seen on the neck—faintly on some, more plainly on others. Head and neck of many macerated. Cirrus extended in some cases, when it was seen to be relatively stout and smooth. These specimens bear a close resemblance to *Distomum* sp. from *Enchelyopus cimbrius* (see Parasites of Fishes of Woods Hole Region, fig. 330), which may be a specimen of *D. tenue* from which the oral spines have fallen away.

Dimensions of specimen with elongated neck, in millimeters: Length 7.5; diameter, at oral sucker 0.21, at pharynx 0.51, at ventral sucker 0.6, from which point the diameter is nearly uniform to the posterior end; diameter of oral sucker 0.18, of pharynx 0.18, of ventral sucker 0.27; length of pharynx 0.2; distance of pharynx from anterior end 1.05; distance of ventral sucker from anterior end 2.25; ova 0.076 by 0.043. Another specimen with contracted neck measured 5 mm. in length; distance of pharynx from anterior end 0.3 mm.; distance of ventral sucker from anterior end 0.75 mm. The ova were undergoing segmentation.

12. *Distomum* sp. [Figs. 213, 214.]

Three, with extraordinarily voluminous intestines which obscure other organs. Same as No. 10 under *Coryphæna equisetis*.

Dimensions, in millimeters, slightly compressed: Length 3.35; diameter, anterior 0.11, at ventral sucker 0.33, nearly uniform to posterior end; oral sucker, length 0.10, breadth 0.08; ventral sucker, circular, 0.24 in diameter.

These specimens are immature. There is no pharynx. The œsophagus is slender. The intestinal rami begin in a convoluted mass slightly in front of the ventral sucker, and continue to the posterior end, being voluminous, and apparently irregularly constricted, so as to present the appearance of a series of translucent bodies filling the post-acetabular region of the body. The intestines are filled with structureless, seemingly colloid material. No trace of genitalia could be made out in any of these distomes.

While they are immature, there should be no difficulty experienced in recognizing these peculiar forms.

### **Coryphæna equisetis**, *Small Dolphin.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1902.<br>August 21 | 3 | Fish. |

These dolphins were taken by the Fisheries steamer *Fish Hawk* about 28 miles off Cape Lookout. They agree with descriptions of this species in length of maxillary, profile of head, number of spines in dorsal and anal fins, coloration, and size. Length 20 to 24 inches.

### NEMATODES.

1. *Filaria galeata* sp. nov. [Fig. 20.]

See No. 1 under *Sphyrna tiburo* (figs. 17–19).

Numerous fragments from stomach. These worms have the appearance of having been introduced into the stomach of the dolphin along with some host in which they were adult. A number of these were males with only the posterior ends preserved. These fragments, while agreeing closely with the species described from the bonnet-head shark, present some differences. The posterior ends were simply curved in a helix instead of a spiral. This, however, may be accounted for by the flaccid condition of the specimens, due, presumably, to the digestive fluids of the dolphin.

The long spicule of the male (fig. 20) was winged at the distal end so as to resemble the fluke of an anchor.

The fragments of females contained ova in which young had already developed. It should be noted that the ova had lain in sea water for two days before they were examined. They varied somewhat in size. The best formed ova measured 0.032 by 0.018 mm. in the two principal diameters.

### CESTODES.

2. *Scolex polymorphus* Rudolphi.

Numerous, small, but with two costæ developed on the bothria.

3. *Blastocyst.*

One, with no indication of larva. It resembles the kind of which *Rhynchobothrium speciosum* is a type.

### TREMATODES.

4. *Distomum tornatum* Rudolphi.

Numerous, mainly from the stomach; 247 were counted.

5. *Distomum monticellii* Linton.

A few smallish, immature specimens appear to belong to the species which I have been recording under this name.

6. *Distomum appendiculatum* Rudolphi.

Some small slender distomes agree closely with this species.

7. *Distomum nigroflavum* Rudolphi.

Four, 3 adult and 1 young.

8. *Distomum tenue* Linton.

Forty-nine were counted. These agree with those from the common dolphin referred to this species.

9. *Distomum dentatum* Linton.

Two small distomes were found which differ from No. 8 in being flattened dorso-ventrally instead of having a cylindrical shape. They resemble this species, but are devoid of oral spines.

10. *Distomum* sp. [See figs. 213, 214.]

Six. These are the same as No. 12 under the common dolphin. Their most conspicuous character is the very voluminous intestinal rami which obscure the other organs, if any are yet developed, but which are themselves translucent.

### PARASITIC COPEPODS.

11. *Lernæonema* sp.

Numerous on dorsal fins and sides; on all, but most abundant on one of the fish; egg-chains variously colored, green and purple; all with heads deeply buried in flesh of host.

12. *Caligus* sp.

One; yellowish-brown.

**Centropristes striatus**, *Black Sea-bass.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| August 2 | 1 | Fish, crabs, shrimp. |
| August 3 | 3 | Crabs. |
| August 5 | 1 | Fish and crustaceans. |
| August 7 | 7 | Fish, crabs (hermit crabs and others). |
| August 8 | [illegible] | Fish and crustacea (crabs and isopods), bryozoa (*Bugula*). |
| August 10 | 1 | Fish, crabs, annelids, bryozoa, seaweed. |
| August 12 | 6 | Fish, crabs, mollusks. |
| August 13 | 6 | Fish, crabs, bivalve mollusks, annelids. |
| August 15 | 2 | Fish, crabs, shrimp, isopods. |
| August 16 | 1 | Fish, crabs, shrimp, bivalve mollusks. |
| August 22 | 2 | Crabs, sea-urchin (*Moiera atropos*). |
| Do | 1 | Crabs. |

All the fish were rather small, many of them from 4 to 5 inches in length.

In 1902, from July 7 to August 19, 45 fish, all small, were examined. The contents of the alimentary canals comprised fish, crabs, shrimp, amphipods, and other small crustacea, annelids, 1 ophiuran, and sea lettuce.

### NEMATODES.

1. *Immature nematodes* (*Ascaris*). [Fig. 33.]

Type with diverticula to intestine and œsophagus.

1901.—Aug. 2, rather numerous, small on viscera. Aug. 3, 7, 12, 13, 16, 22, and 27, few on each date.

1902.—July 8, few; July 17, 1; July 19, 3; July 21, 1; July 22, several. A few, noted on July 14, 16, 22, which differed from the others in having a more distinctly clavate œsophagus; the subcuticular layer was conspicuously cellular.

2. *Immature nematodes* (*Ascaris*).

Type with elongated basal part of œsophagus and corrugated post-anal region.

1902.—July 29, few.

### CESTODES.

3. *Scolex polymorphus* Rudolphi.

1902.—July 25; elongated forms with 2 costæ on bothria and 2 red pigment patches on the neck.

4. *Rhynchobothrium* sp.

Probably larval stage of *R. plicatum* sp. nov.

1902.—July 16, 1. This specimen was found free in the water of a small dish in which the viscera had been lying. It had doubtless escaped from a cyst. The specimen was very active. The proboscides were not seen extended, but the hooks, seen through the body wall, suggest this species. Length 2.5 mm.; length of head and neck 0.8 mm.

5. *Rhynchobothrium* sp. [Fig. 94.]

Probably encysted stage of *R. longispine* Linton.

Small, oval, or pyriform cysts in viscera and mesentery; larvæ small, with relatively long contractile bulbs, and with hooks of various sizes, but some of them relatively rather large. Length of longer hooks 0.027 mm.

Same form recorded from various hosts in these notes, Aug. 5, 7, 8, 10, 12, 13, 17, 22, 27, 1901.

1902.—July 17, 21, 25, 29, and Aug. 12, 19; few to numerous. Some cysts were opened which had no trace of larva in the blastocyst.

6. *Rhynchobothrium* sp.

1901.—Aug. 10, 1 larva from small cyst on viscera noted which belongs to a type found in other hosts; characterized by elongated neck and proboscides armed with minute hooks. Probably *R. tenuispine* Linton.

1902.—July 16, 1; Aug. 15, 1.

7. *Otobothrium dipsacum* Linton.

1901.—Aug. 12, a single specimen from a blastocyst on the viscera.

8. *Cestode larva.*

Apparently a larval *Dibothrium.*

1902.—July 19, 1, encysted on viscera.

TREMATODES.

9. *Distomum monticellii* Linton. [Fig. 158.]

1901.—Aug. 10, a single immature appendiculate distome from intestine. Dimensions, compressed, in millimeters: Length 1.82; breadth 0.81; diameter of oral sucker 0.22, of pharynx 0.15, of ventral sucker 0.39. Color yellowish, intestine very voluminous; pharynx conical, the larger anterior end contiguous with the oral sucker.

1902.—July 14, 1. This specimen is immature. The reproductive organs are rudimentary, the intestines voluminous. In front of the ventral sucker and just behind it the excretory vessel is filled with orange-colored spherical concretions. Dimensions of living specimen in millimeters: Length 1.17; breadth 0.35; oral sucker, length 0.09, breadth 0.10; pharynx, length 0.054, breadth 0.050; ventral sucker, length 0.22, breadth 0.24.

10. *Distomum tenue* Linton.

1901.—Aug. 12, 1, probably a young specimen of this species. Spines on the ventral surface, low, flat, and rounded, those on the margins of the neck relatively long. The marginal spines disappear about the posterior third. The ventral spines in the oral circles are very small and slender, while the dorsal spines are stout. In this particular the specimen exhibits considerable variation from the typical form of this species. Dimensions in millimeters, specimen compressed: Length 1.68; breadth 0.5; diameter of oral sucker 0.14, of ventral sucker 0.25; pharynx, length 0.21, breadth 0.17.

1902.—July 17, 1. This specimen agrees with this species, except that the spines are missing.

## **Orthopristis chrysopterus**, *Hog-fish.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| July 10 | [illegible] | Annelids and vegetable débris. |
| July 11 | 6 | Amphipods, large numbers of fragments of annelids; spines and pieces of test of sea urchin (*Moira*). |
| July 12 | 8 | Bivalve mollusks, crabs, annelids, and sand. |
| July 17 | 10 | Fiddler crabs, amphipods, several small horseshoe crabs (*Limulus*), bivalve mollusks (*Solenomya* and *Venus*), annelids, test of sea urchin, fragment of ophiuran, and large numbers of what were taken to be eggs of *Limulus*. |
| July 20 | 10 | Broken shells of bivalve mollusks, annelids, and sand. |
| July 27 | 2 | Fragments of shells and annelids. |
| July 30 | 10 | Broken shells of lamellibranch mollusks (two or more species), gastropods, annelids, tests and spines of sea urchin, seaweed. |
| July 31 | 5 | Annelids (*Arenicola*), mollusks, etc. |
| August 3 | 1 | Broken shells, sand, etc. |
| August 6 | 10 | Mainly broken shells and sand, young *Limulus*. |
| August 7 | 1 | Fish, broken shells, crustacea, sand. |
| August 17 | 7 | Shrimp, broken shells, annelids, sand. |
| August 28 | 3 | Shrimp, broken shells (lamellibranchs), univalves (*Urosalpynx*), annelids, sea urchin. |
| August 30 | 1 | Fish, shrimp, lamellibranchs, annelids. |
| August 31 | 7 | Fish, shrimp, annelids. |
| 1902. | | |
| July 8 | 11 (small, 50-60 mm.) | Shrimp, small lamellibranchs, and gastropods, seaweed. |
| July 11 | 3 (small, 50-60 mm.) | Shrimp, small gastropods, annelids. |
| July 15 | do | Amphipods and other small crustacea, copepods. |
| July 16 | 2 (small, 50-60 mm.) | Small shrimp, amphipods, copepods, lamellibranchs (*Solenomya*), annelids, sand. |
| July 19 | 5 | Crab, shrimp, lamellibranchs, small gastropods, sand. |
| Do | 3 | Crab, shrimp, small lamellibranchs, annelids. |
| July 21 | 1 | Shrimp, lamellibranchs (*Solenomya*), annelids. No entozoa. |
| July 22 | 1 | Crab, shrimp. No entozoa. |
| July 25 | 1 | Shells of *Solenomya*. |
| July 28 | 1 (small) | Shells of *Solenomya*, annelids. |
| July 31 | 4 | Shrimp, amphipods, *Solenomya*, annelids, sea urchin testes. |
| August 1 | 6 (small) | Shrimp, lamellibranchs, annelids. |
| August 8 | 1 | Small crustacea. No entozoa. |
| August 11 | 5 | Fish, scales, crabs, shrimp, lamellibranchs, gastropods, spines of sea urchin, sand. |
| August 12 | 3 | Lamellibranchs, gastropods, seaweed. |
| August 13 | 4 | Amphipods and other small crustacea, annelids. No entozoa. |
| August 16 | 6 (5 small) | Gastropods, shrimp, annelids. |
| August 18 | 2 | Lamellibranchs, annelids, sea urchin (*Moira*). |
| August 19 | 6 | Lamellibranchs, crabs, shrimp. |
| August 20 | 5 | Crabs, annelids, sea urchin (*Moira*). |
| August 21 | 5 (small) | Shrimp, amphipods, copepods, *Solenomya*. |

The fish examined in 1901 were from the market and were of the usual size; those examined in 1902 were taken in a small seine and were all small.

### ACANTHOCEPHALA.

1. *Echinorhynchus pristis* Rudolphi.

1901.—July 20, 7. July 27, 1. July 30, 5. July 31, few and small. Aug. 6, few and small. Aug. 7, fragment of female. Aug. 28, 1, fragment.

1902.—July 19, 2. July 25, 2. July 31, 5. Aug. 11, 4. Aug. 18, 1.

2. *Echinorhynchus sagittifer* Linton.

1901.—Aug. 6, 1, from mesentery.

### NEMATODES.

3. *Immature nematodes* (*Ascaris*).

1901.—July 27. This is the type characterized in this paper as possessing a diverticulum on both intestine and œsophagus. A few cysts found July 20, 1901, although containing nothing recognizable, were probably due to these nematodes. Aug. 6, nematodes, same type as those found on July 27. Aug. 7, several cysts from mesentery and serous coat of stomach containing degenerate, waxy tissue; no entozoa found in them, but they are probably due to these nematodes. Aug. 28, same type as of July 27. The diverticulum of the œsophagus was elongated and slender. In the larger specimens the intestine was dark brown.

1902.—July 19, 25, 31, Aug. 12, few on each date.

### CESTODES.

4. *Scolex polymorphus* Rudolphi.

1901.—Aug. 31, few, in intestine, with two red pigment spots and simple bothria.

1902.—July 14, 1, active, 2 costæ, no red pigment. July 15, ordinary type, also minute forms. Aug. 18, few, large. Aug. 20 and 21, few, small.

5. *Rhynchobothrium* sp. [Fig. 98.]

Hooks suggest *R. plicatum* sp. nov.

1901.—July 12, cysts containing type with elongated neck and proboscides armed with small, but not minute, hooks. July 17, several, encysted on viscera. Diameter of proboscis, including hooks, 0.017 mm.

1902.—Aug. 20, 1.

See No. 9, under *Bairdiella*.

6. *Rhynchobothrium* sp.

1901.—July 17, cysts containing small larvæ of the type recorded in field notes as being small with relatively long hooks and bulbs. July 27, small, encysted. Aug. 17 and 28, small oval cysts on viscera.

1902. July 25 and 31, few, small oval cysts.

7. *Rhynchobothrium* sp.

1901.—Aug. 31, larvæ from blastocyst. This is the type recorded in these notes as slender with very long proboscides armed with very minute hooks.

8. *Otobothrium crenacolle* Linton. [Fig. 110.]

1901.—Aug. 6, cyst with two blastocysts, each with a larva. Upon compressing the cyst the larvæ could be made out through the transparent walls to belong to this species. Diameter of cyst 2 mm.

9. *Tetrarhynchus bisulcatus* Linton.

1901.—July 31, few. Aug. 28 and 30, scolices encysted in stomach wall.

10. *Synbothrium* sp. See introduction.

1901.—July 11, 1, cestode larva, which is probably to be referred to this species. The cyst was found in the liver, and measured 25 mm. in length and 3 mm. in diameter. The blastocyst was about the same size as the enveloping cyst and was very active. When flattened, marginal sinuous vessels were seen, but no appearance of a larva. The killed specimen measured 14 mm. in length. July 12, a cyst similar to the foregoing found on this date yielded a larva which appears to belong to this species. Dimensions in millimeters: Length 6; breadth of head, 1.2; diameter of neck, 0.6; length of contractile bulbs 1, diameter 0.27; diameter of proboscis, exclusive of hooks, 0.1; specimen somewhat compressed.

11. *Cestode larva.*

Same as No. 8, under *Micropogon undulatus.*

1902.—Aug. 16, 2, with crumpled bothria and striated neck—probably *Anthobothrium pulvinatum.*

12. *Cysts.*

1902.—July 8, cysts on viscera, probably cestode, but no larvæ found.

### TREMATODES.

13. *Distomum appendiculatum* Rudolphi. [Fig. 152.]

1902.—July 14, a single specimen found in a small piece of the intestine, which was under examination for food under the compound microscope. The specimen was small, yellowish by transmitted and whitish by reflected light; excretory vessel white by reflected, dark by transmitted light; body crossed by fine transverse lines, active, contracting to 0.6 mm. in length and 0.45 mm. in breadth and extending to twice that length, at the same time narrowing proportionally.

Dimensions, life, in millimeters: Length 1.26; maximum breadth, just behind ventral sucker, 0.41; oral sucker, length 0.060, breadth 0.075; pharynx, length 0.054, breadth 0.036; ventral sucker, length 0.16, breadth 0.17, becoming nearly circular at times; ova, 0.025 by 0.011.

14. *Distomum vitellosum* Linton.

1901.—Aug. 31, 1. A fragment of a distome which resembles this species was found on this date.

15. *Distomum globiporum* Rudolphi.

1901.—July 11, 1. White, long, oval specimen belongs to this species or is near it. Dimensions in millimeters: Length 5.5, breadth 2.5; diameter of oral sucker 0.56, of pharynx 0.4, of ventral sucker 0.84; ova, 0.08 and 0.05 in the two principal diameters.

The following notes were made at the time of collecting: Pharynx globular, close to oral sucker, esophagus short, genital aperture immediately behind pharynx; intestinal rami simple, probably extending to posterior end; cirrus lying along median line, pouch dorsal to ventral sucker; ovary globular, 0.3 mm. in diameter, close behind ventral sucker and a little to the left; testes two, close together, about on median line, the anterior one near the posterior edge of the ventral sucker; vitellaria voluminous, filling posterior half of body and extending laterally to about middle of neck; ova only moderately abundant.

16. *Distomum corpulentum* sp. nov.

1901.—Aug. 28, a small, nearly spherical distome which agrees with No. 14 under *Lagodon rhomboides.* The surface of this specimen was roughened by exceedingly minute toothed or crenulate transverse lines. These appear in some places to be low blunt teeth. Dimensions in millimeters: Length 2.8; diameter of oral sucker 0.15, of ventral sucker 0.57; ova, 0.037 and 0.02 in the two principal diameters.

17. *Distomum bothryophoron* Olsson. [See figs. 174, 175.]

1901.—July 10, 1. When lying free in sea water this distome was rather plump, smooth, but with fine transverse wrinkles. Pharynx nearly globular and contiguous with oral sucker; œsophagus none or very short; ova very numerous, obscuring other organs; apertures of both oral and ventral suckers transverse; genital aperture on median line just behind pharynx. Dimensions in millimeters: Length 3.24, breadth, median and maximum 1.19; oral sucker, length 0.18, breadth 0.21; ventral sucker, length 0.64, breadth 0.78; pharynx, diameter 0.1; ova, 0.051 and 0.024 in the two principal diameters. July 11, Figs. 174, 175 made from this specimen. July 30, 1, small. Dimensions in millimeters: Length 1; oral sucker, length 0.08, breadth 0.11; ventral sucker, diameter 0.31; pharynx, diameter 0.05; breadth of body, anterior 0.11, middle 0.43, posterior 0.11; ova, 0.044 and 0.017 in the two principal diameters.

1902.—July 8, 1. July 19, 2. July 25, 1. July 31, 5. Aug. 19, 1.

Rather plump, fusiform, often pale red. The flattened and stained specimens show the presence of a lobed vitelline gland like that of *D. bothryophoron.* The specimens found on July 8 and 25 were about as broad as long, and at first were taken to be representatives of a different species, but upon being cleared up show the characteristic vitellaria of this species and also agree in other particulars. Length 1.35 mm., breadth 1.35 mm.; another length 1.8 mm., breadth 0.9 mm.

18. *Distomum areolatum* Rudolphi.

1901.—Aug. 31, 1. A small specimen which belongs to this species or near it, agreeing with No. 16 under *Micropogon undulatus*. Dimensions in millimeters: Length 1.12; breadth 0.45; diameter of oral sucker 0.14, of pharynx 0.08, of ventral sucker 0.09; ovum, 0.12 and 0.08 in the principal diameters. Posterior part of body filled with minute oval bodies, 7 and 4 microns in the two principal diameters.

1902.—Aug. 11, 1 and fragment, immature. Aug. 19, few.

19. *Distomum tenue* Linton.

1901.—Aug. 30, a single specimen in close agreement with No. 6 under *Sciænops ocellatus*, found on the same date, appears to belong to this species, although no spines could be made out either around the mouth or on the body. There were indications, however, that spines had been present in both situations. The intestine in front of and beside the ventral sucker was gorged with granular material of a faint orange color; the remainder of the worm was white. Dimensions in millimeters: Length 4; diameter, maximum 0.75, of oral sucker 0.19, of pharynx 0.28, of ventral sucker 0.3; distance from anterior end of pharynx 0.77, of ventral sucker 1.45; ova, 0.11 and 0.08 in the two principal diameters.

20. *Distomum valde-inflatum* Stossich.

1901.—July 11, 1, from cyst on viscera. Dimensions in millimeters: Length 2.1; breath 1.12; diameter of oral sucker 0.15, of ventral sucker 0.22; pharynx, length 0.18, breadth, 0.14.

21. *Gasterostomum* sp. (?)

1901.—July 11, 2 small slender trematodes, in too poor condition to admit of determination, rather suggest this genus.

22. *Monostomum vinal-edwardsii* Linton.

1901.—Aug. 31, 1.

1902.—Aug. 11, 1.

23. *Monostomum* sp. [Fig. 222.]

1901.—Aug. 28, 2, small, short oval. Dimensions in millimeters: Length 0.86; breadth 0.65; diameter of oral sucker 0.14, of pharynx 0.06; ova, 0.021 and 0.014 in the two principal diameters; cirrus densely spinose. This species appears to be near the small form found in *Pomolobus* (Bulletin of U. S. Fish Commission for 1899, p. 439, fig. 377.) Aug. 30; 2, small, oval, resemble the foregoing, but the body is covered with minute spines, a feature not observed in the former lot. Aug. 31, few; same as those collected on the preceding date.

24. *Monostomum* sp. [Figs. 223–225.]

1901.—July 30, 1, rather slender when compressed, and bearing numerous ova, which are peculiar in that their longer diameter is three times the shorter. Dimensions in millimeters: Length 0.9; diameter, anterior 0.15, middle 0.25, posterior 0.08; diameter of oral sucker 0.14; pharynx, length 0.05, breadth 0.04; diameter of genital aperture 0.08; ova, 0.03 and 0.01 in the two principal diameters. Aug. 31, 1.

1902.—July 15, several, found in pieces of the intestine with the aid of the compound microscope. They are very irregular in shape and of considerable variety of size; dirty greenish-yellow by transmitted, paler by reflected, light. Dimensions of 7 specimens chosen at random, life, length, and breadth only: Length 0.30, breadth 0.24; length 0.34, breadth 0.24; length 0.18, breadth 0.15; length 0.15, breadth 0.13; length 0.25, breadth 0.19; length 0.30, breadth 0.18; length 0.19, breadth 0.16. When compressed these specimens become uniformly long oval, larger anteriorly, tapering posteriorly, and then are easily seen to be identical with the specimens taken in 1901.

25. *Monostomum* sp. [Figs. 216, 218.]

These are slender forms which were represented by only a few specimens, which were quite fragile and otherwise in poor condition, so that the anatomy revealed by them is very incomplete.

The general shape of the body is long and slender, especially in the specimens collected on Aug. 11 (fig. 216). The vitellaria are represented by a number (as many as 25 in one) of subglobular bodies, situated not far from the middle of the length of the body. Ova numerous, the convolutions of the uterus extending to the posterior end. Oral sucker and pharynx each longer than broad, the latter remote from the mouth.

1902.—July 18, 1 (fig. 218 sketched from this specimen). Dimensions in millimeters, life, compressed: Length 1.4, breadth 0.3; oral sucker, length 0.16, breadth 0.11; pharynx, length 0.12, breadth 0.09; genital sucker 0.10; ova, 0.025 by 0.011. Aug. 11, 3. Aug. 18, 1. These were not recognized as agreeing with the specimen collected on July 18, and unfortunately the preserved material does not allow of a comparison, part of it having been lost or destroyed by accident.[a] Fig. 216 was sketched from one of the specimens collected on Aug. 11. Dimensions of living specimen, slightly compressed, in millimeters: Length 1.8; diameter at anterior end 0.12; maximum diameter 0.27; oral sucker, length 0.15, breadth 0.10; pharynx, length 0.09, breadth 0.07; diameter of genital sucker 0.11. Another specimen measuring 2.25 in length had other dimensions agreeing almost exactly with the above. Ova, 0.18 by 0.14.

26. *Diclidophora* sp.

1902.—Aug. 12, 1, small, from gills. This specimen was very fragile, the posterior finger-like processes appearing to be somewhat macerated. Dimensions, in millimeters: Length 1.86, length exclusive of posterior sucker 1.28; diameter at anterior end 0.08; maximum diameter of body 0.52, of sucker region 0.96; diameter of one of the 8 small suckers 0.13.

### COPEPOD PARASITES.

27. *Ergasilus* sp. From gills.

1902.—Aug. 18, 2, females. Thorax yellowish on border, reddish in center, abdomen red; posterior appendages yellowish, transparent, tinged with pink at the base; egg chains lavender, very long.

These specimens, together with others collected last year, were sent to Prof. C. B. Wilson, who informs me that he finds in the lot the two genera *Bomolochus* and *Ergasilus*.

## **Lagodon rhomboides**, *Pin-fish.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| July 12 | 7 | An abundance of green seaweed and a few amphipods and annelids. |
| July 16 | 2 | Seaweed, amphipods, small crabs, and fragments of fish. |
| July 18 | 1 | Small bivalve mollusks, amphipods, and annelids. |
| August 5 | 1 | Fish, bivalve mollusks, and sea lettuce. |
| August 8 | 1 (small) | Fish, seaweed. |
| August 10 | do | Fish. |
| August 12 | 2 (small) | Fish, amphipods, copepods, bryozoa, vegetable débris, and sand. |
| August 13 | 2 | Fish, crabs. |
| August 17 | 8 | Bivalve mollusks, shrimp, annelids. |
| August 20 | 15 | Fish, sea lettuce. |
| August 21 | 16 | Fish, fœces (fish taken at laboratory wharf). |
| August 22 | 11 | Fish, sand (same locality). |
| August 23 | 12 | Fish, seaweed, sand, fœces (same locality). |
| August 24 | 11 | Fish, bivalve mollusks, crabs, sea lettuce, sand. |
| August 27 | 2 | Fish, crab, spines of sea urchin (*Moira*), gorgonia spicules, seaweed, sand. |
| 1902. | | |
| July 7 | 35 (small) | Shrimp, seaweed, small gastropods, and sand. |
| July 14 | 8 (small, 50 mm.) | A small piece of the intestine contained many spines and other fragments of annelids and fragments of small crustacea. |
| July 15 | 1 (small) | Sand with foraminifera, etc. |
| July 16 | 6 (50–125 mm.) | The alimentary canals of the small fish contained small shrimp and amphipods; those of the larger fish contained broken lamellibranch shells, spines of sea urchin, and fragments of seaweed. |
| July 17 | 6 (small) | Small shrimp and amphipods. |
| July 18 | 1 (small) | Small crabs, gastropods, seaweed. |
| July 19 | 4 | Sea-urchin spines, lamellibranchs, seaweed. |
| July 21 | 3 | Vegetable débris; no entozoa. |
| July 22 | 1 | Young shrimp, small lamellibranchs; no entozoa. |
| August 8 | 4 | Crabs, lamellibranchs, seaweed. |

### ACANTHOCEPHALA.

1. *Echinorhynchus pristis* Rudolphi.

1901.—July 12, a single specimen, female, is referred provisionally to this species; from intestine. Color yellowish white, proboscis and anterior end of body each partly inverted. Dimensions, in millimeters: Length 11, of proboscis 1.22, of sheath 2, of lemnisci 1.68; greatest diameter 0.53, of proboscis at base 0.14, middle and apex 0.15, of lemnisci 0.04, of ovarian masses 0.16 and 0.11 in the two principal diameters; embryos 0.068 and 0.017 in length and breadth respectively. The body was slender fusiform, tapering from 0.53 mm. at near anterior end to 0.35 mm. at the middle and 0.25 mm. near posterior end. The anterior end was inverted, but was seen to be rather abruptly tapering to proboscis and armed near the proboscis with sagittate spines; a few scattering sagittate spines also on the uninverted anterior end of the body. Base of proboscis armed with a circle of about 12 relatively long and but slightly recurved hooks; anterior to this circle about 16 vertical rows of small, blunt hooks, about 6 in each row; anterior to these the hooks are arranged in the ordinary spirals, the basal for a short distance short, stout, and recurved, the remainder, so far as seen, of usual type, viz., stout and recurved on one side of the proboscis, and slender, straightish on the other; about 8 hooks visible in a single spiral. Proboscis nearly at right angles to axis of body.

---

[a] In searching for these specimens in the vial in which they had been placed two slender specimens of *Distomum pectinatum* were found, which had not been noted from this host at the time of collecting. They are not given a number in this report, since it is possible that they may have been placed in the vial by mistake.

2. *Echinorhynchus sagittifer* Linton.

1901.—Aug. 22, encapsuled on viscera.

NEMATODES.

3. *Immature nematodes* (*Ascaris* sp.).

1901.—Aug. 20, 21, 24, few, from body cavity on viscera. These belong to the kind characterized in this paper as having diverticula of œsophagus and corrugated post-anal region. (Type shown in fig. 31.)

CESTODES.

4. *Scolex polymorphus* Rudolphi.

1901.—July 16, few in intestine. Aug. 5, few. Aug. 10, 1. Aug. 20, few; red pigment spot noted. Aug. 21, few; two red spots noted in these. Aug. 23, few. Aug. 27, few. All of these larval cestodes found in intestine.

1902.—July 14, several minute specimens were seen in a small piece of the intestine which was being examined under the compound microscope in order to ascertain the nature of the food. The bothria were all retracted and evidently still rudimentary. These minute forms were of nearly uniform size; length 0.14 mm.; breadth 0.06 mm.; color yellowish-white. Other specimens were also observed, which were larger and of the usual type. July 15, rather numerous, with red pigment patches, but no costæ on the bothria.

5. *Cestode blastocysts.*

1901.—July 16, 1, on viscera; no larva yet developed. Aug. 17, 1; slender, from viscera; active after several hours in sea water.

6. *Rhynchobothrium* sp.

Probably encysted stage of *R. longispine* Linton.

1901.—Aug. 23, 1. This appears to be the kind which is recorded in these notes as small, with relatively long hooks and contractile bulbs. From cyst on viscera.

1902.—July 7, 15, 19 and Aug. 8, few. Small, oval cysts on viscera.

7. *Otobothrium crenacolle* Linton.

1902.—Aug. 24, 1 cyst with larva.

8. *Tetrarhynchus bisulcatus* Linton.

1901.—July 18, from cyst.

TREMATODES.

9. *Distomum monticellii* Linton.

1901.—Aug. 20, 1, from intestine. Dimensions, in millimeters, compressed: Length 4.2; diameter of oral sucker 0.27, of ventral sucker 0.52, of body 0.56; ova, numerous, 0.028 and 0.014 in two principal diameters. Color light red; cirrus pouch in front of ventral sucker; testes close together placed somewhat diagonally and immediately behind the ventral sucker; ovary somewhat farther back, followed by the lobed vitellaria; rami of intestines extend to posterior end of body. Aug. 21, 2, young, 1.13 and 2 mm. in length respectively. The stained specimens show the testes, ovary, vitellaria, and rudiment of cirrus pouch, all agreeing with this species.

In each specimen in life the excretory vessel, just behind the ventral sucker and just in front of it, was filled with spherical, orange-colored concretions. These varied from very minute to 0.01 mm. in diameter.

10. *Distomum appendiculatum* Rudolphi.

1902.—July 18, 1, small distome, not in good condition, agrees closely with this species; ova 0.014 by 0.011.

11. *Distomum vitellosum* Linton.

1901.—Aug. 24, 1, from intestine.

12. *Distomum pyriforme* Linton.

1901.—Aug. 20, 4. Dimensions, in millimeters, of largest specimen, compressed: Length 1; breadth 0.42; diameter of oral sucker 0.07, of pharynx 0.04, of ventral sucker 0.09; ovum 0.068 and 0.034 in two principal diameters; smallest specimen, length 0.53, breadth 0.29. Aug. 23, 1, not in good condition.

1902.—Aug. 8, 3, not in good condition, belong to this species or are near it. Dimensions, life, in millimeters: Length 1; breadth 0.5; diameter of oral sucker 0.08, of pharynx 0.05, of ventral sucker 0.09.

13. *Distomum* sp. [Fig. 179.]

1901.—Aug. 17, 1, somewhat macerated. Dimensions, in millimeters: Length 2; diameter 1, of oral sucker 0.38, of pharynx 0.28, of ventral sucker 0.25; ovum 0.075 and 0.058 in two principal diameters.

14. *Distomum corpulentum* sp. nov. [Figs. 180–182.]

Body unarmed, subspherical, ventral sucker much larger than oral, sessile, prominent, aperture transversely elliptical, mouth subterminal; pharynx contiguous to oral sucker; œsophagus very short. Each branch of the intestine with a short diverticulum prolonged anteriorly, parallel with the pharynx. testes two, lateral behind the ventral sucker; ovary between the right testis and the ventral sucker; cirrus pouch muscular in front of ventral sucker and a little to the right, vitellaria lateral. The species has many points of resemblance to *D. pagelli* Beneden.

1901.—Aug. 21, 3, small and nearly spherical. One of the specimens was pinkish or light orange, when viewed by transmitted (artificial) light, the ova, which filled all the post-acetabular region, were seen to be amber-yellow, while the suckers, particularly the ventral sucker, were brownish-red. Dimensions of larger specimen, flattened under cover-glass, in millimeters: Length 2.25; breadth 1.74; oral sucker, length 0.21, breadth 0.29; pharynx, length and breadth each 0.12; ventral sucker, length 0.73, breadth 1.16; ovum 0.051 and 0.027 in the two principal diameters. Dimensions of a second smaller and paler specimen under same conditions: Length 1.54; breadth 1.26; oral sucker, length 0.17, breadth 0.21; pharynx, length 0.13, breadth 0.10; ventral sucker, length 0.46, breadth 0.83; ova, irregular, maximum, 0.041 and 0.024; others 0.027 and 0.020, 0.030 and 0.015, 0.027 and 0.017, respectively, in the two principal diameters. An unflattened specimen, which had lain in formalin over night, but which had not sensibly changed its proportions, had the following dimensions: Length 0.77; breadth 0.75; thickness 0.63. Aug. 23, 24, 1 on each date.

### **Archosargus probatocephalus**, *Sheepshead.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| July 8 | 1 | Crustacea, spines and fragments of tests of sea-urchins. |
| August 3 | 1 | Hermit crabs and other crustacea, comminuted shells and Gorgonia spicules. |

No entozoa were found in the alimentary canals of these fish, which is not surprising when one considers the nature of the contents of stomach and intestine, which would act as a mechanical anthelmintic.

### PROTOZOA.

1. *Myxobolus* (*Henneguya*) sp.

Aug. 3, a small white patch on one of the pectoral fins, about 2 mm. in length, was found to contain spores which appear to be identical with those found in the intestinal wall of the drum (*Sciænops ocellatus*) and pompano (*Trachinotus carolinus*). About the only difference noted was that the caudal prolongation of the shell was longer in these than in those from the drum. The length of the body was barely 0.01 mm., while the length of the spore, including the caudal spicule, was from 0.03 to 0.04 mm.

### **Diplodus holbrookii**, *Spotted Pin-fish.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1902 | | |
| July 22 | 2 small | Bryozoa. |

COPEPOD PARASITES.

1. *Argulus* sp.

Few; found in washings from intestine, but doubtless from outside of host.

NEMATODES.

2. *Lecanocephalus annulatus* Molin.

One, a female, length 5 mm. Other dimensions, life: Diameter, of head 0.2, of body at base of œsophagus 0.5; middle of body 0.67, maximum diameter, a little behind middle, 0.85; length of œsophagus 0.9; diameter of body at anal aperture 0.18; distance from anal aperture to posterior end 0.16.

CESTODES.

3. *Scolex polymorphus* Rudolphi.

Few, minute, seen in a small piece of the intestine which was being examined to ascertain the character of the food.

### **Eucinostomus gula**, *Silver Jenny.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1902. | | |
| August 20 | 1 (small) | In a small piece of the intestine were found spines, setæ and hooks of annelids, eyes of small crustacea, diatoms, fragments of vegetable tissue, and sand. |
| August 21 | 5 (small) | Annelids. |

NEMATODES.

1. *Small nematodes.* [Figs. 49, 50.]

Aug. 21, a male, which agrees with No. 6 under *Leiostomus xanthurus.*

### **Kyphosus sectatrix**, *Rudder-fish, Chub.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1902. | | |
| August 23 | 1 | Crabs, lamellibranchs, vegetable débris, and sand. |

NEMOTODES.

1. *Ascaris* sp.

Fragments of a female. Dimensions in millimeters of alcoholic specimen: Length 20; diameter, maximum, 0.6, at anterior end 0.24, at anal aperture 0.3; distance from anal aperture to posterior end 0.45; length of œsophagus 3.5; ova 0.06 by 0.03. There was but one jaw left on the specimen: Length, 0.18; breadth, 0.15. There was a short diverticulum to the intestine and one to the œsophagus as in *A. habena.* The jaw also suggested that species. The œsophagus was cylindrical and the intestine had thick walls.

**Cynoscion regalis**, *Squeteague, Weak-fish, Gray Trout.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| July 6 | 3 | Fragments of fish and legs of large shrimp. |
| July 10 | 3 | Fragments of fish. |
| July 15 | 2 | Do. |
| July 17 | 4 | Do. |
| July 19 | 4 | Fish, crabs, and shrimp. |
| July 22 | 3 | Fragments of fish and seaweed. |
| July 29 | 2 | A few fragments of broken shells. |
| July 30 | 2 | Fish. |
| August 1 | 4 | Do. |
| August 6 | 2 | Fish, lamellibranchs, crustacea. |
| August 7 | 1 | Fish, shrimp. |
| August 12 | 1 | Fish. |
| 1902. | | |
| July 16 | 9 | Fish, shrimp. |
| August 13 | 1 (small) | Shrimp. |
| August 18 | 1 | Fish, shrimp, lamellibranch. |
| August 19 | 1 | Do. |
| August 20 | 2 (small) | Fish, shrimp, annelids. |

### ACANTHOCEPHALA.

1. *Echinorhynchus pristis* Rudolphi.

1901.—July 17, 1, a female. There was also found in this lot the posterior end of a female of this genus which was provided with papillæ. [Figs. 15, 16.]

2. *Echinorhynchus sagittifer* Linton.

1901.—August 6, 1, immature, from mesentery.

### NEMATODES.

3. *Ascaris* sp. Immature.

1901.—July 17, several on viscera; type with diverticulum on both œsophagus and intestine. There were also in this lot numerous yellowish cysts on the mesentery. No entozoa were found in them, but they resemble cysts from which immature nematodes have been obtained on many occasions. July 19; numerous in mesentery. Same type as above; one examined carefully showed the rudiments of jaws characteristic of *Ascaris*. Many cysts also in the mesentery, some if not all of which were due to these nematodes. July 22; 1. July 29; few. Aug. 6, 7, 12; few on each date.

1902.—July 16, numerous, in yellowish cysts on viscera; the larger specimens with dark-brown intestine. July 19; numerous, in waxy cysts on viscera; intestine red-brown.

### CESTODES.

4. *Scolex polymorphus* Rudolphi.

1901.—July 6, many, from alimentary canal; two pigment spots on neck. July 10; in gall bladders, not numerous; pigment spots; rudiments of costæ on bothria. July 15; larger forms in cystic duct; smaller in alimentary canal. July 17; numerous, from cystic duct. July 22; few in gall bladders. July 29; few. July 30; very numerous in cystic duct. Aug. 1, 6; many in cystic duct. Aug. 12, few.

1902.—July 16, Aug. 13, 18, 19, 20, numerous, in cystic duct and intestine, those in the latter about one-sixth as long as those from the cystic duct.

5. *Rhinebothrium* sp.

1901.—July 22. This agrees with type found in the toad-fish.

6. *Rhynchobothrium* sp.

1901.—Aug. 7. Cysts in clusters on mesentery. Type with long neck and minute hooks.

7. *Rhynchobothrium speciosum* Linton.

1902.—July 16, several.

8. *Otobothrium crenacolle* Linton.

Encysted in walls of alimentary canal.

1902.—Aug. 18, few. Aug. 19; several.

9. *Tetrarhynchus bisulcatus* Linton.

1901.—July 17, encysted in stomach wall, not numerous. July 19, Aug. 6, 7, and 12; few on each date. July 30; a few cysts with degenerate tissue found in stomach wall.

1902.—July 16, Aug. 13, 18, 19, 20, few each date.

10. *Synbothrium* sp. [Figs. 116–118.]

See introduction and No. 13 under *Pomatomus*.

1901.—July 19, 1, on viscera; larva with curved hooks. Aug. 1; 1, an elongated blastocyst; while no larva could be made out in this specimen, the resemblance of the blastocyst to this species was very close. Aug. 12; 1, blastocyst from viscera.

1902.—July 16, 1, blastocyst, length 93 mm.

### TREMATODES.

11. *Distomum vitellosum* Linton.

1901.—July 30, a single small specimen, without ova, and in poor condition; resembles *D. vitellosum*, but with pharynx and acetabulum relatively smaller than usual in that species.

1902.—Aug. 13, 1, small, immature.

12. *Distomum polyorchis* Stossich.

In vicinity of pyloric cæca.

1901.—July 17, 1; length 6, breadth 1.4; 14 testes visible on each side. Specimen not in good condition. July 19; 14 collected from 4 trout.

1902.—July 16, 5. Aug. 18; 3.

13. *Distomum* sp.

1902.—Aug. 13, 1. This is identical with No. 4 under *Spheroides maculatus*.

14. *Microcotyle* sp.

1902.—Aug. 18, 4, small, length 1.5 mm. from gills. The specimens were in poor condition.

## **Cynoscion nebulosus**, *Spotted Weak-fish.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901 | | |
| July 15 | 1 | Fragments of fish in stomach. |
| July 22 | 2 | Fish and shrimp. |
| July 29 | 1 | Alimentary canal empty. |
| July 31 | 4 | Fish. |
| August 21 | 2 | Fish, crabs, and shrimp. |
| August 28 | 5 | Fish, shrimp, jaws of an annelid. |
| August 31 | 2 | Fish. |
| 1902. | | |
| August 11 | 1 (small, 150 mm.) | Fish, shrimp. |

### NEMATODES.

1. *Immature nematodes* (*Ascaris* sp.)

1901.—July 15, 22, 29, few. July 31; numerous, on viscera. These were noted as belonging to type designated in these notes as having a slender diverticulum extending caudad from base of œsophagus and a short diverticulum extending cephalad from anterior end of intestine. July 31; clusters of cysts on rectum; tissue degenerate, somewhat waxy; in others the contents were of the nature of fine-grained, tenacious masses in a semifluid. Aug. 28; 20 or more. Intestine of larger specimens dark brown; œsophagus relatively short; diverticula as in preceding; post-anal region rather short-conical. There were also numerous cysts of degenerate tissue on the mesentery which appear to be due to this worm.

1902.—Aug. 11, few.

### CESTODES.

2. *Scolex polymorphus* Rudolphi.

1901.—July 29, 31, few; from intestine; small with prominent anterior sucker. Aug. 21; few; collected from cystic duct. Aug. 28; numerous; not seen in the cystic duct by Mr. Stone, who collected them, but they resemble those collected on former occasions from the cystic duct of this fish and of *C. regalis*. Aug. 31; rather numerous; larger specimens in cystic duct; smaller in intestine; bothria simple; 2 red pigment spots in neck.

1902.—Aug. 11, 1, large, red pigment in neck.

3. *Rhynchobothrium* sp.

1901.—July 15, a slender larva from cyst on viscera; length of bothria 0.21 mm.; anterior end of bulbs 3.7 mm. from anterior end of scolex. The hooks bear some resemblance to those of *R. plicatum*.

4. *Otobothrium crenacolle* Linton. [Figs. 112-114.]

1901.—July 15, in cysts, very numerous in submucosa of stomach. The cysts were small; an average blastocyst measured 1.2 mm. in length and 0.7 mm. in breadth. Dimensions of larva in millimeters: Length 0.5; breadth of bothrium 0.16; diameter of neck 0.11; length of contractile bulbs 0.072, breadth 0.034; length of proboscis 0.45; diameter exclusive of hooks 0.017. July 22; large numbers of small oval cysts in stomach wall. A few of these were opened and the blastocysts liberated. They contained larvæ which were immature, but under pressure the characteristic pits on the borders of the bothria and the position of the contractile bulbs could be made out. Aug. 28; small cysts, numerous, in stomach wall.

5. *Tetrarhynchus bisulcatus* Linton.

1901.—Aug. 28, scolices encysted in stomach wall; associated with No. 4.

### TEMATODES.

6. *Distomum monticellii* (?) Linton.

1901.—July 29, 1, an appendiculate distome from the intestine; dull yellowish-white, finely and transversely wrinkled when contracted. Length very variable while living. When the length was 3.6 mm. the breadth was 1.8 mm.; alcoholic specimen, length 2.63 mm., breadth 0.87 mm. Dimensions, in millimeters in life, specimen compressed: Oral sucker, length 0.31, breadth 0.38; pharynx, length 0.22, breadth 0.18; ventral sucker, diameter 0.83. The larger anterior end of pharynx included in oral sucker; intestinal rami long. This specimen was stained and sectioned, but the reproductive organs remained indistinct. Aug. 28; 1, probably same species, immature. So far as can be made out this specimen agrees with *D. monticellii*. It agrees very closely with No. 15, under *Micropagon undulatus*.

7. *Distomum tenue* Linton.

1901.—Aug. 21, 1, agreeing with this species, or more nearly with the variety *tenuissime*. This specimen was in a macerated condition when studied, and there were no spines on the body or around the mouth. The following notes were made on the specimen after it had been in weak formalin over night. Dimensions in millimeters: Length 3.5; breadth 0.45; oral sucker, length 0.13, breadth 0.15; pharynx, length 0.19, breadth 0.12; ventral sucker, length 0.24, breadth 0.22, three ova present, length of each 0.092, shorter diameters 0.044, 0.048, and 0.051, respectively. Testes long oval, following each other closely on the median line, near the posterior end, the anterior one closely preceded by the ovary. Vitellaria rather sparse, but distributed as in *D. tenue*, viz., peripheral in posterior region. Pharynx near ventral sucker, distance from ventral sucker 0.2, from oral sucker 0.7. Aug. 28; 1. This specimen has the general arrangement of its anatomy like this species, but with the habit of body rather more like *D. dentatum*, and with oral spines missing. Dimensions, life, in millimeters: Length 2.8; breadth 0.46; transverse diameter of oral sucker 0.17, of pharynx 0.1, of ventral sucker 0.19, no ova; pharynx remote from mouth; cirrus pouch behind ventral sucker.

8. *Distomum valde-inflatum* Stossich.

1902.—Aug. 11, few; in cysts with greenish-yellow waxy secretions on viscera.

**Bairdiella chrysura**, *Silver Perch*, *Yellow-tail.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| August 10 | 5 | Small crustaceans and annelids. |
| August 12 | 16 (small) | Fish, shrimp, amphipods, and annelids. |
| August 13 | 9 | Great abundance of teeth and spines of annelids, and a few amphipods. |
| August 15 | 2 | Fish, crabs, shrimp. |
| August 16 | 2 | Shrimp. |
| August 21 | 1 (small, 85 mm.) | Annelids. |
| August 22 | 5 (small, 85 mm.) | Food material completely digested except a minute fragment of a shrimp and the zoaea of a crab. |
| 1902. | | |
| July 14 | 4 (50 mm. or less) | Small crustacea. |
| July 16 | 26 (small) | Shrimp, shell of *Solenomya;* sand in intestine. |
| July 17 | 6 (small) | Spines of annelids. |
| July 19 | do | Shrimp and other small crustacea (*Caprella*, etc.). |
| July 21 | 5 | Shrimp. |
| July 25 | 6 | Shrimp and small gasteropod (*Olivia*). |
| July 29 | 5 | Shrimp. |
| August 4 | 2 | Do. |
| August 5 | 1 small | Contents of alimentary canal completely digested. |
| August 8 | 5 | Shrimp and annelids. |
| August 11 | 5 | Crabs, shrimp, and small lamellibranchs. |
| August 12 | 3 | Crabs, shrimp. |
| August 18 | 1 | Small crustacea. |
| August 19 | 5 | Food not noted. |
| August 21 | 5 | Do. |

ACANTHOCEPHALA.

1. *Echinorhynchus pristis* Rudolphi.

1902.—July 16, 2. July 19, 2. July 25, 1. Aug. 12, 1.

NEMATODES.

2. *Immature nematodes* (*Ascaris*).

1901.—Aug. 10, few, from body cavity; small; type found in many hosts, i. e., with slender posterior diverticulum on œsophagus and short anterior diverticulum of intestine. Aug. 12, few. Aug. 13, few. These are probably the same as the foregoing, although only the diverticulum of the œsophagus could be made out. Posterior end of these worms acuminate. Aug. 15, few; diverticula easily made out, that from the œsophagus long and slender.

1902.—July 16, several, encysted on viscera. July 17; several, from clusters of yellowish cysts on mesentery. July 21; 2, encysted on viscera. Aug. 8, 11, 18, few, and very small on each date.

3. *Immature nematodes* (*Ascaris*).

Type with elongated basal part of œsophagus and corrugated post-anal region.

1902.—Aug. 11, few, associated with No. 2.

CESTODES.

4. *Scolex polymorphus* Rudolphi.

1901.—Aug. 12, few, small.

1902.—July 14, these were very small and had been overlooked when the viscera were examined with the aid of the hand lens. A small piece of the intestine was examined under the compound microscope in order to ascertain the nature of the food, when minute parasites were noticed amid the intestinal contents. These were recognized as belonging to this group of immature cestodes. Dimensions when compressed, in millimeters, length 0.2, breadth 0.18. July 16, several. July 25, several; Aug. 5, several, small. Aug. 21, few, minute.

5. *Cyst in stomach wall.*

1902.—Aug. 11, an elongated blastocyst was obtained from this cyst, but no larva was yet developed in it.

6. *Nodular cysts.*

1902.—Aug. 11, on the stomach, intestine, in the mesentery and in the substance of the liver. These cysts suggested the occurrence of sporozoa, but no entozoa of any kind were found in them. The fish from which they were obtained was reported by Mr. Stone to be in poor condition and to have an enlarged and bloated abdomen in which there was an accumulation of serous fluid.

7. *Rhynchobothrium* sp.

Type characterized by slender larva, long neck, exceedingly minute hooks, from fusiform cysts on viscera. *R. tenuispine* Linton is suggested.

1902.—Aug. 12, 1.

8. *Rhynchobothrium* sp. [Fig. 93.]

1901.—Aug. 10, numerous on viscera in pyriform cysts. This is the type seen in many hosts, and characterized in these notes as small, with relatively long hooks. The larva is short, and the hooks are of various sizes and shapes. The larger hooks are relatively long when compared with the size of the larva. A similar remark may be made respecting the contractile bulbs. Dimensions of a living larva, in millimeters: Length 1.54; length of head 0.35, of contractile bulbs 0.5, of longer hooks 0.04. Both this species and the following (No. 9) were found in the black bass (*Centropristes striatus*) on the same date. Both hosts were taken at the jetty near Fort Macon. Their food habits are practically identical. Aug. 12, cysts on viscera; one of these was examined and the contained larva appeared to be a very immature stage of this species.

1902.—July 25, several. July 29, few.

9. *Rhynchobothrium* sp. [Fig. 97. See also fig. 98.]

1901.—Aug. 10, cysts on viscera. These contain relatively elongated larvæ. A type found in other hosts, but not of such frequent occurrence as No. 8. See under *Centropristes.* The neck is long, the proboscis sheathes in a close spiral in ordinary conditions of contraction; proboscides rather long, the hooks relatively short and close together. Dimensions of a living larva, compressed, in millimeters: Length 3.85; length of head 0.46, of contractile bulbs 0.43, of longest hooks 0.014.

1902.—Aug. 19, from fusiform cyst on viscera, the hooks suggest *R. plicatum*, similar to specimen from *Orthopristis chrysurus* collected Aug. 20.

10. *Otobothrium crenacolle* Linton.

1901.—Aug. 12, small cysts from viscera in which were blastocysts containing larvæ. These were rudimentary but appeared to belong to this species. Aug. 15, 2 larvæ from cysts in body cavity. Such numbers as here given do not represent the actual number in the fishes examined on this date. It may be added that in the majority of instances where this species was found at all it was found in comparatively large numbers.

1902.—July 17, 19, Aug. 8, encysted on viscera and mesentery.

11. *Tetrarhynchus bisulcatus* Linton.

1901.—Aug. 12, rather numerous, encysted in stomach wall.

1902.—Aug. 13, numerous in stomach wall. Aug. 15, 1 encysted in stomach wall. Aug. 5, 11, 18, 19, 21, few on each date; cysts in stomach wall.

### TREMATODES.

12. *Distomum monticellii* Linton.

1901.—Aug. 13, 1. In this specimen the testes are close behind the ventral sucker, where they are perhaps crowded forward by the voluminous folds of the uterus, which are filled with ova. The ovary is separated from the posterior testis by folds of the uterus, and is itself followed by the vitellaria. The latter are lobed, having about three lobes on each side. The shell gland is at the junction of the lobes of the vitellaria just back of the middle of the ovary. Cirrus pouch in front of the ventral sucker, a little to the left; genital aperture on median line of the neck, just back of origin of intestinal rami. Dimensions of living specimens, compressed, in millimeters: Length (appendix partly retracted) 3.2; maximum diameter 0.5; diameter of oral sucker 0.2, of ventral sucker 0.42, of pharynx 0.08, ova 0.024 by 0.014.

13. *Distomum vitellosum* Linton. [Fig. 178.]

1901.—Aug. 10, 2, lobes on the border of the ventral sucker very distinct.

1902.—July 17, 2. July 29, Aug. 4, 8, 11, few on each date. Aug. 19, several. Aug. 21,2.

As usual, the individuals present a great variety of shapes.

In 1901 other small distomes were taken (fig. 170) which probably belong here, although the characteristic lobes around the ventral sucker were not made out. The posterior end is slightly emarginate in all the preserved specimens and the aperture of the ventral sucker is narrow and transverse.

1902.—Aug. 15, 2. Aug. 22, 3. The intestine was very indistinct, but the œsophagus was evidently very short or none. Dimensions, life, in millimeters: Length 1, breadth 0.5; transverse diameter of oral sucker 0.11, of pharynx 0.05, of ventral sucker 0.22; ova (average of two) 0.08 by 0.04.

14. *Distomum* sp. [Figs. 168, 169.]

These differ from the foregoing mainly in the position of the testes.

1901.—Aug. 15, 1. Dimensions, life, in millimeters: Length 0.84, breadth 0.42; oral sucker 0.12, pharynx 0.06, and ventral sucker 0.17 in diameter; ova 0.063 by 0.035. Aug. 16, 2. Aug. 21, 3.

1902.—July 17, few. July 19, 1. July 21, 1. July 29, Aug. 4 and 19, few. The testes in some are placed somewhat diagonally.

15. *Distomum pectinatum* sp. nov. [Figs. 200–203.]

Body elongate, somewhat fusiform, color white, except where the yellow ova show through the translucent walls. Neck narrowing to head, very fragile, and provided with 12 fleshy, papillary lobes, 6 on each side just back of the head. There are also 14 similar lobes, making a crown dorsal and lateral on the head; otherwise the worm is smooth. Ventral sucker much larger than the oral, and situated about the anterior third; pharynx cylindrical, its anterior end touching the oral sucker; œsophagus long; rami of intestines simple, slender, beginning at anterior edge of ventral sucker and extending to posterior end of the body. Testes 2, subglobular, at posterior end of body, near together and placed a little diagonally. Cirrus-pouch rather large, with coiled cirrus, on left side contiguous to the anterior edge of the ventral sucker; genital aperture in front of ventral sucker on left of median line. Ovary in front of testes, as far as or farther than the diameter of a testis, and on the right of the median line. Uterus very voluminous, filling the body from the posterior testis to the ventral sucker, and extending thence laterally to the cirrus on the left side to the genital aperture. Vitellaria distributed laterally from the anterior testis nearly to the ventral sucker. They appear to be much reduced in the specimens studied. Ova minute, of two kinds, oval and nearly spherical, the latter larger than the others and seen near the middle of the body.

Dimensions in millimeters, life, specimen collected Aug. 10, 1901: Length 2.1; greatest breadth, specimen compressed, 0.38; oral sucker, length 0.12, breadth 0.10; pharynx, length 0.21, breadth 0.11; ventral sucker, length 0.28, breadth 0.25; most of the ova 0.022 by 0.015 in the two principal diameters; a few were seen which were nearly spherical, about 0.018 by 0.017. The head and especially the neck quickly macerate.

1901.—Aug. 10, 2, much macerated. Aug. 12, 5. Aug. 13, 18. Aug. 15, 8. Aug. 16, 1. Aug. 21, 3. Aug. 22, 20.

1902.—July 16, 1. July 17, 8. July 19, numerous, one small piece of the intestine 4 mm. in length yielded 10. July 21, 8. July 25, 10. July 29, 10. Aug. 4, 5. Aug. 5, 6. Aug. 8, 40. Aug. 11, 5. Aug. 12, 3. Aug. 18, 6. Aug. 19, 17. Aug. 21, 6. The specimens collected on Aug. 6 were more slender than the type but do not appear to be specifically different.

16. *Distomum areolatum* Rudolphi.

1902.—Aug. 8, numerous. These specimens agree closely with the species which I have referred in former papers to *D. areolatum.* Dimensions of a living specimen, slightly compressed, in millimeters: Length 0.75, breadth 0.40; diameter of oral sucker 0.11, pharynx 0.05; ventral sucker 0.08. The one ovum measured 0.12 by 0.07 in the two principal diameters.

### COPEPOD PARASITES.

17. *Caligus* sp.

1902.—July 16, 1. Found in washings from intestine but doubtless from outside of its host.

18. *Parasitic copepod* (*Lernanthropus*).

1902.—Aug. 19, 2. Aug. 21, 1; from gills.

**Sciænops ocellatus**, *Red Drum.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| August 9 | 5 | Shrimp. |
| August 10 | 1 | This specimen was about 20 inches in length; contents of alimentary canal completely digested. |
| August 15 | 2 | Fish, crabs, shrimp. |
| August 30 | 1 | Fish. |
| 1902. | | |
| July 18 | 1 (250 mm.) | Crabs, shrimp. |
| July 30 | 1 | Food not noted. |

PROTOZOA.

1. *Myxobolus* (*Henneguya*) sp. [Fig. 56.]

1901.—Aug. 10, the pyloric cæca and beginning of the intestine of the fish examined on this date were almost completely covered with white bodies 2 mm. or less in diameter. Twenty-four of these bodies were counted in a space 15 mm. square. The sporozoa were oval, about 0.013 mm. in length, 0.010 mm. in greatest breadth and 0.006 mm. thick, with a slender posterior spicule of about the same length as the body of the sporozoon. The cell wall is relatively thick, the two oval bodies of the usual shape and of a faint greenish color. When first liberated in sea water there appeared to be a third body behind the oval bodies. Later this could not be seen. The caudal spicule was straight in most, but not infrequently was curved.

The fish had been caught several hours before it was examined and the mucous membrane had sloughed off, leaving the cysts exposed on the inner side of the intestine when it was opened; they showed quite plainly also from the outside, their color being an opaque dead white. Numerous minute, highly refractile bodies were seen to be scattered among the sporozoa where the cysts were flattened on the slide.

See also under *Archosargus probatocephalus* and *Trachinotus carolinus.*

NEMATODES.

2. *Heterakis* sp. [Figs. 24, 25.]

("*Ascaris* (?) sp.," from *Paralichthys dentatus* No. 6, p. 481, pl. VII, figs. 57–61, Parasites of Fishes of the Woods Hole Region.)

1901.—Aug. 9, 1. This specimen has two prominent post-anal papillæ. There is no indication of spicules. Dimensions in millimeters, life: Length, 5; diameter, anterior 0.4, middle 0.5, at anal aperture 0.08; distance of anal aperture from posterior end 0.18; length of œsophagus 0.67.

A specimen similar to this was found in the flounder (see No. 6 under *Paralichthys albiguttus*). It was at first supposed to be a male, but upon examination it was found to be a female, the reproductive aperture being situated two-fifths of the whole length from the posterior end.

See also under *Leiostomus*, and *Lophopsetta*, and introduction for remarks on *Heterakis.*

CESTODES.

3. *Scolex polymorphus* Rudolphi.

1901.—Aug. 30, few. July 30, few.

TREMATODES.

4. *Distomum vitellosum* Linton. [Figs. 176, 177.]

1901.—Aug. 9, numerous; great variety of shape and size as in *Menticirrhus americanus.* In certain stages of little contraction the border of the ventral sucker, which is undulate when moderately contracted, is deeply lobed or even fimbriate. Some of the specimens while still in sea water had become rigid and turgid, with prominent ventral sucker. In the latter case the characteristic border of the ventral sucker is obliterated. In one specimen under pressure the testes appeared to be lobed. Relative dimensions agreed with published descriptions. Aug. 15, 6. Aug. 30, 12. In this lot a surprising variety of shape, and particularly in the condition of the ventral sucker, was found. In some the ventral sucker was seen to be surrounded by four lobes, each of which is denticulate or fimbriate, having four or more processes. When seen in dorsal or ventral view this feature is not conspicuous, but in lateral view, when the ventral sucker is prominent and its border uncontracted, it becomes a very conspicuous object. In some positions these lobes suggest by their outline the fore foot of a mole.

1902.—July 18, 4. July 30, few.

5. *Distomum areolatum* Rudolphi.

1902.—July 18, 6. These agree closely with the species which I have been recording under this name. The outline, however, is oval-elliptical, with the greatest diameter at the middle of the length, or a little in front of the middle. July 30; 6, small, oval, yellowish; posterior end, when first seen, emarginate; body with a dense covering of minute spines.

6. *Distomum tenue* Linton.

1901.—Aug. 9, 3, resembling this species, although there were no oral spines. Dimensions in millimeters: Length 3.6; diameter 0.65, about uniform for the posterior two-thirds, i. e., from the ventral sucker to the posterior end; transverse diameter of oral sucker 0.19, of the circular ventral sucker 0.26; pharynx, length 0.28, breadth 0.26; ova, average of four, 0.09 and 0.06 in the two principal diameters. Aug. 15, 3, long and slender, same as foregoing. Aug. 30, 4. The cuticle on the neck of these was thrown into rather coarse folds, at least on the margins, probably an evanescent and possibly an accidental character. It gave to these specimens a very characteristic appearance. Dimensions in millimeters: Lengths of two measured 2.6 and 4.5. Further dimensions of the latter: Diameter, maximum, 0.6, of oral sucker 0.2, of ventral sucker 0.3; pharynx, length 0.3; breadth 0.18; distance of pharynx from anterior end 0.8.

1902.—July 18, 4, and several others which appear to be the young of this species.

**Leiostomus xanthurus**, *Spot.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901 | | |
| July 11 | 1 | Crustacea, mainly shrimp. |
| July 12 | 2 | Broken shells of small bivalve mollusks, amphipods, ostracodes, and green seaweed, |
| July 17 | 12 | Ostracodes, sand with a few small bivalve mollusks with much vegetable débris. |
| July 19 | 10 | Large quantities of broken shells of bivalve mollusks, amphipods. |
| July 30 | 3 | Large quantities of broken shells, with small spines of sea-urchin and sand. |
| Do | 7 | Broken shells, many; a few annelids, shrimp, and amphipods; much sand. |
| July 31 | 2 (specimens small, 60 mm. in length.) | Fragments of shells and sand. |
| August 10 | 4 (small) | Bivalve mollusks and shrimp. |
| August 17 | 1 (small) | Small gasteropod and lamellibranch shells; copepods; spines of sea-urchin and sand. |
| August 24 | 1 | Bivalve mollusks, shrimp, annelids. |
| August 30 | 3 | Fish, shrimp, lamellibranchs and small univalves, sea-urchins. |
| 1902. | | |
| July 8 | 14 (small) | Shrimp, small lamellibranchs, sea-urchins, sand. |
| July 16 | 6 (small) | Small spines of sea-urchins, ostracode shells, very small isopods, sand. |
| July 17 | do | Shrimp, small gastropod shells (*Olivia*), sand. |
| July 19 | do | Mainly small crustacea; no entozoa. |
| July 21 | 5 (small) | Shrimp, green vegetable débris. |
| July 22 | do | Amphipods, small gastropods, annelids. |
| July 23 | 6 (small) | Spines of sea-urchin and broken lamellibranch shells. |
| July 25 | 1 (small) | Mainly amphipods. |
| July 28 | 7 (small) | Ostracodes, copepods, annelids, spines of sea-urchin, sand. |
| July 29 | 4 (small) | Spines of annelids, diatoms. |
| July 31 | 5 | Broken shells, small gastropods, two small sea-urchins. |
| August 1 | 5 | Broken shells, sea-urchin spines. |
| August 4 | 4 (small) | Lamellibranchs, ostracodes, spines of sea-urchin, annelids. |
| August 7 | 1 | Lamellibranchs, gastropods, small crustacea, bryozoa, spines of sea-urchin. |
| August 8 | 5 (small) | Lamellibranchs, entomostraca, annelids, spines of sea-urchin. |
| August 11 | 5 | Shrimps, sea-urchin, sand. |
| August 13 | 4 | Shrimps, sea-urchin, sand; no entozoa. |
| August 16 | 1 | Lamellibranchs, sea-urchin spines, sand. |
| August 18 | 2 | Do. |
| August 21 | 5 (small) | Small lamellibranchs, copepods, annelids, spines of sea-urchins, sand. |

The sea-urchin spines were those of the common spatangoid *Moira atropos*. The sand so commonly found in the alimentary canal of the spot doubtless comes from the intestines of this sea-urchin.

### ACANTHOCEPHALA.

1. *Echinorhynchus pristis* Rudolphi. [Figs. 8–14.]

1901.—July 12, 2. July 17, 11, some white, others translucent, others yellowish and others pink. July 19, 7; translucent, white, pinkish and orange-yellow individuals. Length of female 16 mm., of male 7 mm. July 30, 15 from one lot, 8 from another; same colors as above; one male noted which was white but with an orange bursa. When placed in fresh water these worms become turgid. Aug. 30, 1. This species is well adapted to maintain its hold on the mucous membrane of its host by means of the long and slender thorny proboscis and the attenuated anterior end of the body, which is likewise armed with spines. These appliances, together with the tough tissues of the body, are all doubtless needed to preserve the worms when exposed to the anthelmintic action of broken shells and sea-urchin spines which are frequently found filling the entire length of the alimentary canal of the fish.

1902.—July 16, 1 fragment. July 23, 3. July 25, 2. Aug. 13, 1.

### NEMATODES.

2. *Immature nematodes* (*Ascaris* sp.).

1901.—July 11, 1, encysted on viscera; posterior end conical, anal aperture with prominent lips, mouth simple; July 17, several, small; a single diverticulum extending posteriorly from base of œsophagus noted. A small cyst in this lot, when opened, liberated a minute nematode; July 30. This seen plainly to be the type of most common occurrence, viz., with a diverticulum extending posteriorly from the base of the œsophagus and an anterior prolongation of the intestine. Also found in another lot of fish examined later on this same date.

1902.—July 8, 2.

3. *Ascaris habena* Linton.

1902.—July 23, 1, female; length 28 mm.

4. *Heterakis* sp.

1901.—July 19, 1, female. This worm agrees closely with No. 2 under *Sciænops ocellatus*. Dimensions in millimeters, life: Length 2.1, length of œsophagus 0.46; diameter, anterior, 0.15; middle 0.22, at anal aperture 0.06; distance of anal aperture from posterior end 0.77; distance of genital aperture from anterior end 0.4. See also under *Lophopsetta* and *Paralichthys*.

5. *Small nematodes*. [Figs. 35–42.]

These, which may indeed represent different species, were seen by me for the first time in the summer of 1902. They are minute nematodes provided with a few bristles, especially near the anterior end, a circular pit on each side of the head, and the body curved much like the letter C. Such minute forms, while of much interest, are rather too small for satisfactory study in the kind of survey contemplated in this report.

1902.—July 8, few; minutely, but distinctly, transverse-corrugate. Usually with a few straight, slender, sharp spines at the anterior end and sparsely scattered on the body. This feature was not observed on all. Reproductive aperture of female near the middle of the body. A single comparatively large ovum and what were taken to be several smaller ova were noted. Dimensions of a female, life, in millimeters: Length 1.4; length of œsophagus 0.22; diameter, anterior 0.043, at genital aperture 0.086, at anal aperture 0.046; distance of genital aperture from anterior end 0.75; distance of anal aperture from posterior tip, 0.075. July 28, rather numerous, very small. Aug. 4, few, same type as foregoing, among them one male, which was larger than the females, and may belong to another species. The tail was much elongated. The spicules are shown in figure. Aug. 8, few, males and females. If these really belong to the same species there is a remarkable difference between the heads of the two sexes. Fig. 35 shows a view of the posterior end of a male from this lot. Aug. 11, 5, identical with those found on July 8. Aug. 18, several, males and females. The females agree with type of July 8. The head of the male differs from this type, see figs. 38 and 39. Length, 1 mm. Aug. 21, few, same as type of July 8, minute, bristly, with circular pit on each side of head.

6. *Small nematodes*. [Figs. 43–48 and 51–54.]

1902.—July 17, 2, males. [See figs. 53 and 54.] Dimensions, life, in millimeters: Length 3; diameter, head 0.045; at base of œsophagus 0.09, from which point it is nearly uniform to the anal aperture; distance of anal aperture from posterior tip 0.18; length of œsophagus 0.42; œsophagus nearly cylindrical, increasing uniformly from 0.045 to 0.06 in diameter; length of copulatory spines 0.12. The papillæ were not made out very satisfactorily; about 16 were counted in lateral view, very minute, and all preanal. The most posterior papilla was nearly 0.4 millimeter in front of the anal aperture. From this the papillæ continue at nearly regular intervals for about 0.8 millimeter. July 25, 2. [See figs. 45 and 46.] One of these, a female, yielded the following measurements in millimeters: Length 2; length of œsophagus 0.36; distance from anal aperture to posterior tip 0.18; diameter of head 0.03, at anal aperture 0.04, at genital aperture 0.07; distance of genital aperture from posterior end 0.54. July 28, 1 male, associated with No. 5, but about three times as long. [See figs. 43 and 44.] July 29, 2, same type as those of July 17 and 25.

CESTODES.

7. *Scolex polymorphus* Rudolphi.

1901.—July 19, few; intestine. July 31, few, small; intestine.

8. *Larval Cestode.*

1901.—July 17, a flask-shaped, slender larva, associated with No. 10.

CESTODES.

9. *Rhynchobothrium* sp.

Probably larval stage of *R. longispine* Linton.

Type with oval cysts; small larva with relatively long hooks.

1901.—July 1, small cysts on viscera.

1902.—July 17, 22, Aug. 7, 11, few on each date. The hooks on the specimens collected in 1901 were noted as resembling those figured in Proceedings of the National Museum, vol. XIX, pl. LXIII, figs. 4, 5.

10. *Tetrarhynchus bisulcatus* Linton; encysted in stomach-wall.

1901.—July 17, few. July 19, 1. July 30, 1 in one lot; several in another on same date. Aug. 10, 2 Aug. 24, 1. Aug. 30, 1.

TREMATODES.

11. *Distomum appendiculatum* Rudolphi.

1902.—Aug. 21, 1. Dimensions of living worm in millimeters: Length 1; diameter 0.23; diameter of oral sucker 0.06, of ventral sucker 0.13; ova 0.025 by 0.011.

12. *Distomum monticellii* Linton.

1902.—Aug. 21, 1, not in good condition.

13. *Distomum vitellosum* Linton.

1902.—July 29, few. July 31, 2. Aug. 8, 11, few. Aug. 16, 2.

14. *Distomum valde-inflatum* Stossich.

1902.—Aug. 8, few, in globular cysts.

15. *Distomum globiporum* Rudolphi. [Figs. 173, 198, 199.]

1901.—July 11, 1, not in good condition. Dimensions in millimeters, life: Length 3; breadth 0.75; diameter of oral sucker 0.22, ventral sucker 0.25; pharynx length 0.15; breadth 0.11; ovum 0.096 and 0.062 in the two principal diameters. July 17, 2; in one of the worms ova were noticed which were beginning to segment. No spines were noted on the foregoing, while those collected on the three following dates were armed with spines which, however, were small and inconspicuous. These have many points in common with a distome from *Opsanus tau* (Bulletin U. S. Fish Commission for 1899; A. p. 469; fig. 324). Aug. 10; 1, a distome with low, flat, squarish spines along dorsal side and along margins of neck. Color, dirty greenish-yellow by transmitted light. Dimensions in millimeters, life: Length 3.3; breadth 1.26; diameter oral sucker 0.42, ventral sucker 0.52; pharynx, length and breadth each 0.12; œsophagus short, about length of pharynx; intestinal rami extending nearly to posterior end; suckers and their apertures nearly circular. When the specimen was fixed over the flame under pressure the œsophagus contracted so that the branches of the intestine appeared to originate immediately behind the pharynx. Aug. 17; 1 [fig. 198], evidently same species as the specimen collected on Aug. 10, but smaller. Spines on neck and anterior part of body mainly dorsal, ventral spines only in patches on either side of the pharynx. Ova, 0.103 mm. and 0.062 mm. in the two principal diameters, few. Testes two, rather large, median, central, one following the other closely, appearing to be lobed. Ovary subglobular, between anterior testis and ventral sucker, a little to right of median line. Vitellaria posterior and marginal, voluminous. Cirrus pouch dorsal to ventral sucker, aperture close in front of ventral sucker on median line. Aug. 30, 5. These agree with the foregoing. Three ova measured had the following dimensions in microns: 108 by 51, 102 by 65 and 122 by 51. July 30, 2 small, immature distomes [fig. 173], which are probably immature specimens of the foregoing. Dimensions in millimeters, life: Length 0.56 and 0.91, breadth 0.36 and 0.39, oral sucker 0.10 and 0.15, pharynx 0.04 and 0.05, ventral sucker 0.08 and 0.15 respectively.

1902.—July 22, 9. Length of smaller 1.72, of larger 3.75; other dimensions of larger: breadth 1.05; diameter of oral sucker 0.3, of pharynx 0.15, of ventral sucker 0·51; ova 0.10 by 0.06. July 25, few. July 16, 1 and a fragment.

### **Micropogon undulatus**, *Croaker.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| July 6 | 8 | Bivalve mollusks (*Solenomya*); crabs, and other crustacea (many fragments); sand. |
| July 10 | 1 | A few fragments and many spines of annelids. |
| July 11 | 2 | Do. |
| July 16 | 6 | Many fragments of small crustacea. |
| July 20 | | Large number of broken shells of bivalve mollusks; fragments of crustacea; a few pieces of a large annelid, and a quantity of sand. |
| July 27 | [illegible] | Fish, bivalves (*Solenomya*); annelids. |
| July 29 | 3 | Mainly broken bivalve shells. |
| July 30 | 3 | Shells of bivalves, mollusks, annelids, and numerous pieces of a large *Balanoglossus.* |
| August 5 | 1 | Bivalve mollusks, crustacea, annelids. |
| August 5 | 5 | Fish, bivalve mollusks, annelids, sea urchins. |
| August 12 | 1 | Alimentary canal empty, except completely digested material. |
| August 17 | 4 | Bivalve mollusks, annelids, ascidians, sand. |
| August 20 | 8 | Fish, bivalves (*Solenomya*, etc.), sea urchins (*Moira*), annelids, shrimp, and large amount of sand, which doubtless comes from alimentary canals of the sea urchins. |
| August 24 | 1 | Fish, bivalve mollusks, and annelids. |
| August 26 | 6 | Bivalve mollusks, annelids, and *Balanoglossus.* |
| August 31 | 9 | Fish, crabs, shrimp, bivalve mollusks, and annelids. |
| 1902. | | |
| July 7 | 25 (small) | Shrimp, several kinds of lamellibranch and gastropod shells, annelids, sand. |
| July 17 | 5 | Annelids, lamellibranchs. |
| July 18 | 5 | Fish, shrimp, annelids. |
| July 21 | 1 | Lamellibranchs (*Solenomya*), annelid, fragment of sea urchin. |
| July 22 | 4 | Annelids and mollusks. |
| July 25 | 2 | Do. |
| July 31 | 4 | Large annelid (*Arenicola*), shrimp, lamellibranchs (*Solenomya*). |
| August 11 | 1 | Fish, shrimp, lamellibranchs. |
| August 13 | 1 (small) | Shrimp, lamellibranchs, annelids. |
| August 16 | 5 | Do. |
| August 18 | 3 | Shrimp, lamellibranchs, annelids, crabs, sea urchin. |
| August 18 | 3 | Shrimp, lamellibranchs, and gastropods. |
| August 19 | 3 | Annelids and bryozoa. |
| August 20 | 3 | Annelids and lamellibranchs. |

ACANTHOCEPHALA.

1. *Echinorynchus pristis* Rudolphi; intestine.

1901.—July 20, 4, small. July 27, 3. July 29, 2 females and 1 male; one of the former with ovarian masses only, the other with embryos. Aug. 12; 2, male and female, small. Aug. 17, 2. Aug. 24, 1 female; ovarian masses only, no embryos in this specimen. Aug. 31, 2.

1902.—July 7, 9. July 17, 3. July 18, 1. July 22, few. July 31, 1. Aug. 11, 3. Aug. 18, few. Aug. 19, 2. Aug. 20, 1.

2. *Echinorhynchus sagittifer* Linton; body cavity.

1901.—Aug. 26, 1, on viscera.

NEMATODES.

3. *Immature nematodes* (*Ascaris* sp.).

1901.—July 16, few, on viscera. These belong to the type with posteriorly directed diverticulum of bulbous base of œsophagus and anteriorly directed diverticulum of intestine, found in a large number of fish. July 20, few. July 29, 1 small. July 30, few, very small. Aug. 26, few.

1902.—July 18, 25, Aug. 11, 16, 18, 19, few on each date. Also July 31, 1; and Aug. 18, few encysted. Forms with clavate œsophagus, short diverticulum on œsophagus only.

4. *Ascaris* sp.

1901.—July 11, 1 male, small. Posterior three-fourths of the length is of nearly uniform diameter anteriorly attenuate; jaws prominent, breadth nearly equaling length, a single papilla made out on each of the lateral jaws; a posteriorly prolonged diverticulum of œsophagus; spicules slender; post-anal region short. Dimensions in millimeters, life: Length 9, length of œsophagus 0.84; length of diverticulum 0.63; diameter, anterior 0.12, middle 0.37, at anal aperture 0.12; distance anal aperture from posterior end 0.08; distance nerve ring from anterior end 0.24.

5. *Heterakis foveolata* Rudolphi.

1902.—July 25, 1 male, and minute specimen in cyst. See introduction for remarks on *Heterakis*.

CESTODES.

6. *Scolex polymorphus* Rudolphi.

1901.—July 30, few, small, from intestine.

1902.—July 25, few, elongated. July 31, several. Aug. 18, 19, 20, few, small.

7. *Rhinebothrium* sp.

1901.—July 29, a single specimen, immature. While this agrees with the genus *Rhinebothrium* there is a well-defined anterior muscular sucker, which shows relationship with the genus *Echeneibothrium*. The terminal sucker, however, is a character which appertains to the larval stages of a number of cestodes. (See under *Opsanus tau*, 3 and 4.)

8. *Cestode larvæ*. [Figs. 83, 83a.]

These larvæ, much larger than any referred to No. 6, were found on several occasions, and had the borders of the bothria much crumpled or frilled and the neck strongly ribbed longitudinally. They were very active and changed their shape constantly. They were provided with a large terminal sucker, which, if not an embryonic feature, would rather point to the genus *Echeneibothrium* than *Anthobothrium pulvinatum*, which is suggested by the general appearance of the scolex. The terminal sucker was eversible and in some cases became a knob-like proboscis.

1902.—July 17, 2. Aug. 16, 1. Aug. 19, 2. Aug. 20, 3.

Same larvæ found in *Orthopristis* (No. 11).

9. *Rhynchobothrium* sp. [Figs. 87–92.] Cysts in body cavity.

These are larvæ inclosed in their blastocysts and encysted on the viscera, in the mesentery, etc. They belong to the type characterized in these notes as small, with relatively long hooks on the proboscides and relatively long contractile bulbs.

1901.—July 6, numerous on viscera; length of longest hooks 0.03 mm. July 12, numerous cysts on viscera. July 30, several in cluster on mesentery. Aug. 5, few. Aug. 6, numerous small oval cysts clustered on mesentery. Aug. 17, several on viscera. Aug. 20, 1. Aug. 26 and 31, few.

1902.—July 7, 17, 25 and 31, Aug. 11, 16 and 18, clusters on mesentery.

10. *Rhynchobothrium tenuispine* Linton. [Fig. 101.]

1901.—Aug. 31, several larvæ from blastocysts inclosed in cysts on viscera. The first of these seen were in a watch glass of sea water. They had emerged from their cysts and were everted with the blastocysts still attached. The spines are exceedingly minute.

11. *Rhynchobothrium* sp.

Type with hooks suggesting *R. plicatum*.

1902.—July 18, 1 scolex, from cyst on viscera.

12. *Otobothrium crenacolle* Linton.

1901.—Aug. 6, few, from cysts on mesentery associated with No. 9.

1902.—Aug. 11, 1. Aug. 18, encysted in mesentery.

13. *Tetrarhynchus bisulcatus* Linton; stomach wall.

1901.—July 6, numerous, encysted in stomach wall. July 16, 1. Aug. 26, scolices from stomach wall. Aug. 31, cysts in stomach wall. The favorite lodging place of these larvæ both in this and other hosts is in the submucosa of the stomach.

1902.—July 21, 31, Aug. 13, 18, 20, in stomach wall, not numerous.

14. *Synbothrium filicolle* Linton.

From cysts on viscera.

In all cases where these larval forms were examined they were found to belong to the type with slender, straightish hooks.

1901.—July 6, few, on viscera. July 10, 12 from one host, on viscera. July 11, 2. July 16, several. July 20, 1, immature, hooks not developed. July 27, 1, cyst with blastocyst on viscera. The blastocyst was 48 mm. in length. The anterior portion, which contains the larva, is usually very active. It remains attached to the larva when the latter is liberated, thus contributing to the developing strobile in the final host. July 29, 1. July 30, 1, an elongated blastocyst without larva; probably belongs here. Aug. 20, 1. Aug. 26, 1. Aug. 31, numerous. These, as also proved for many of the foregoing, were found to belong to the type with slender, straightish spine-like hooks on the proboscides.

1902.—July 18, Aug. 16, from elongated blastocysts on viscera.

### TREMATODES.

15. *Distomum monticellii* Linton.

1901.—Aug. 17, 1, an appendiculate distome, immature. The reproductive organs could not be made out with certainty. Dimensions of specimen fixed over flame in water, in millimeters: Length 2.5; breadth 0.7; diameter of oral sucker 0.26, of pharynx 0.16, of ventral sucker 0.56. Intestinal rami capacious, extending to but not entering appendix. This specimen agrees very closely with No. 6 under *Cynoscion nebulosus*, collected Aug. 28.

1902.—July 18, 1.

16. *Distomum areolatum* Rudolphi.

1901.—Aug. 31, 1, a small spinose distome, with ventral sucker smaller than oral, œsophagus as long as pharynx, testes side by side toward the posterior end, ova larger than ventral sucker. Dimensions, in millimeters: Length 0.8; breadth 0.46; diameter of oral sucker 0.11, of pharynx 0.04, of ventral sucker 0.08; ovum 0.120 and 0.064 in the two principal diameters, another 0.115 and 0.078. Small oval bodies are present, probably in excretory vessel, which might be mistaken for ova in a worm in which no ova are present. Aug. 6, 1, immature; probably belongs here.

1902.—Aug. 11, 1; Aug. 16, 2; Aug. 18, 12. Some transparent as if macerated, others yellowish and nearly opaque until flattened, densely clothed with spines.

17. *Distomum tenue* Linton.

1901.—July 10, 22. General color of the greater proportion yellowish brown, occasioned by the vitellaria and intestine, lighter colored anteriorly and along median line; of various shapes, but most of them oblong-linear. Dimensions in millimeters: Lengths 1.44, 2.3, and 3; breadths of same three 0.58, 0.60, and 0.44; ovum 0.09 and 0.048 in two principal diameters. Double row of spines around mouth; body covered with scales. July 27, 3. Aug. 6, 1. This specimen appears to belong here, although spines around mouth are wanting. Dimensions in millimeters: Length 5.5; diameter, uniform from ventral sucker to posterior end, 0.7; diameter oral sucker 0.11, ventral sucker 0.35, pharynx 0.35 in length by 0.25 in width; ovum 0.088 and 0.048 in the two principal diameters. Aug. 26, 1. Aug. 31, 3, 1 large, 2 small.

1902.—July 17, 5. July 18, few. Aug. 16, 18, 20, 1 on each date. Aug. 19, 4. Some long and slender; length 7.5 mm.; breadth 1 mm.; others smaller; length 2.5 mm.; breadth 0.3 mm., the latter without ova, some without spines.

18. *Distomum dentatum* Linton.

1902.—July 31, 1, immature. Aug. 11, few.

19. *Distomum valde-inflatum* Stossich.

1902.—July 7, 1, encapsuled. This is probably the young of adult forms like Nos. 17 and 18.

20. *Distomum* sp.

1902.—July 21, 2. Dimensions, life, in millimeters. Length 0.78; maximum breadth 0.5; diameter of oral sucker 0.09, of pharynx 0.05, of ventral sucker 0.07; ova 0.031 by 0.018.

21. *Distomum vitellosum* Linton.

The distomes referred to this species are represented by a very great variety of shapes.

1901.—July 30, 1. This specimen is in almost exact agreement with fig. 336, pl. xxx. Parasites of Fishes of Woods Hole Region, U. S. Fish Commission Bulletin for 1899. Yellowish, body covered with fine, transverse wrinkles, characteristic fimbriæ around the ventral sucker; length 1 mm. Aug. 5, 1. Aug. 17, few. Aug. 24, 3. Aug. 31, 1. It should be noted that as individuals begin to macerate, or even before that, the characteristic lobes or fimbriæ around the ventral sucker disappear.

See remarks on this species under *Menticirrhus*.

1902.—July 7, few. July 17, 3. July 18, several, some transparent, cylindrical, rigid, with prominent ventral sucker, one yellowish, flattened, oval. July 31, 2; 1, length 3.15 mm., remarkable for the elongated posterior region, which was flat and leaf-like, fimbriæ around the ventral sucker prominent. Aug. 11, few. Aug. 16, 12. Aug. 18, 2. Aug. 19 and 20, few on each date.

22. *Distomum simplex* Rudolphi.

In this species the testes are lobed, the body elongated, and there are no lobes around the ventral sucker.

1902.—July 18, 1. July 21, 2. July 22, 1. Dimensions of one, life, in millimeters: Length 4; diameter, anterior 0.21; at ventral sucker 0.5, middle (maximum) 0.6, near posterior end 0.43; diameter of anterior sucker 0.18, of ventral sucker 0.3; pharynx, length 0.11, breadth 0.06; ova 0.07 by 0.04.

23. *Distomum bothryophoron* Olsson.

1902.—July 21, 1, oval, tapering anteriorly. Dimensions, life, compressed, in millimeters: Length 1.2; maximum breadth 0.55; diameter of oral sucker 0.10, of pharynx 0.05, of ventral sucker 0.2; ova 0.018 by 0.014.

24. *Aspidogaster ringens* sp. nov. [Figs. 243–249.]

See No. 11 under *Trachinotus carolinus*.

Usually convex dorsally and concave ventrally. Body proper elongate, tapering at both ends and usually projecting beyond the ventral sucker at each end, but subject to some variation (figs. 244, 245); posterior end conical-pointed. Neck cylindrical, head slightly expanded and divided by a lateral cleft into a three-lobed dorsal and a two-lobed ventral lip. Head and neck often completely retracted. Ventral sucker elliptical, with numerous marginal loculi and marginal sense organs. Thirty-six marginal loculi were found in the specimen sketched in fig. 246. In the same specimen, which was in good condition, there were 17 larger transverse median loculi, with a median ridge not strongly developed, but quite distinct. The ventral sucker is thus divided into 4 longitudinal rows of loculi, and is therefore of the *Aspidogaster* type. In some specimens all the loculi are very indistinct. Dimensions of living specimen, in millimeters: Length 2.57; diameter of head 0.4; pharynx, length 0.16, breadth 0.14; ventral sucker, length 1.61, breadth 1.1; ova 0.103 and 0.058 in the two principal diameters.

Color variable; in general brownish red with anterior end whitish, border of ventral sucker slightly yellowish or translucent. A not infrequent color effect is amber yellow above, purplish red below.

The testis is single, median, usually not far from the middle of the length of the body, but sometimes crowded back to near the posterior end of the conical tail by the voluminous folds of the uterus, which are filled with comparatively large ova and occupy the dorsal and posterior portions of the body. The ovary lies in front of the testis. The vitellaria consist of two elongated lateral masses. The voluminous vas deferens and muscular copulatory organ lie well forward near the anterior margin of the ventral sucker. The genital aperture is on the left side of the neck.

The placing of these specimens in the genus *Aspidogaster* is provisional, since they possess characters which point with almost equal distinctness to *Cotylaspis* and *Cotylogaster*. In a revision of the *Aspidobothridæ* it will doubtless be found to be necessary either to emend the genus *Aspidogaster* or to erect a new genus to accommodate this species.

1901.—Aug. 20, 2. Aug. 31, 3.

1902.—July 17, 1. July 22, 2. July 31, 3. Aug. 11, 1. Aug. 16, 1. Aug. 18, 3.

### PARASITIC COPEPODS.

25. *Anchorella* sp.

1902.—Aug. 20, 2, from gills.

## **Menticirrhus americanus,** *Whiting.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| July 29 | 2 | Fish. |
| Do | 1 | Crustacea (crabs and shrimp). |
| July 30 | 6 | Crabs and shrimp, mollusk shells. |
| July 31 | 1 | Fish and piece of sea lettuce. |
| August 1 | 5 | Almost exclusively shrimp: a few bivalve mollusk shells; also a few shells of Bulla and Urosalpynx. |
| August 6 | 1 | Fish. |
| August 20 | 1 | Crabs. |
| August 24 | 5 | Large numbers of broken lamellibranch shells; a few fragments of small crustacea and sand. |

In 1902, 22 fish, all small, were examined from July 18 to Aug. 20. Annelids, crabs, lamellibranchs, and shrimp found in alimentary canal.

### ACANTHOCEPHALA.

1. *Echinorhynchus pristis* Rudolphi.

1901.—July 29, 1, female. July 30, 2, females; yellow, length 20 and 22 mm. Aug. 1,2, male and female. Aug. 24, 12.

1902.—July 23, 3. July 31, 1. Aug. 1, 1. Aug. 15, 3, small.

### NEMATODES.

2. *Immature nematodes* (*Ascaris* sp.).

1901.—July 29, nematodes belonging to the type which have a slender diverticulum directed posteriorly from the bulbous base of the œsophagus and an anterior prolongation of the intestine. Dimensions of living specimen, slightly compressed, in millimeters: Length 7.2; length of œsophagus 0.77, of diverticulum of intestine 0.21, of diverticulum of œsophagus 0.77; diameter, nearly uniform, 0.22; distance from anal aperture to posterior end, which tapers to an acute point, 0.32. On viscera, some encysted. July 30, 2. July 31, few. Aug. 1, not abundant; from capsules on viscera. Aug. 6, few. Aug. 24, few.

1902.—July 18, few.

3. *Nematode.*

1901.—July 29, slender bodies which appear to be fragments of the ovary of *Ichthyonema* in material from intestine. These exhibit moderately active contractile movements. One piece was about 4 mm. in length and 0.11 mm. in diameter. It was completely filled with elliptical ova 44 by 27 microns in the two principal diameters. In some of these ova young nematodes had already developed.

### CESTODES.

4. *Scolex polymorphus* Rudolphi.

1901.—July 29, few, from intestine; rather larger than usual for these larval cestodes when found in the intestine of their host; red pigment present; terminal sucker very much smaller than bothria. July 31, several, rather large, 2 red pigment patches, 2 costæ on the bothria; also some small. Aug. 6, few.

1902.—July 31, few, small.

5. *Rhynchobothrium* sp.

1901.—Aug. 1, 1, larva released from blastocyst which was inclosed in a fusiform cyst. Dimensions in millimeters: Length 3; length of bothria 0.17, head and neck to base of bulbs 2; length of contractile bulbs 0.36; diameter of head 0.28, of neck 0.14; length of longest hooks 0.01. Bothria and neck to base of bulbs thickly beset with minute bristles. The hooks suggest *R. plicatum.*

6. *Rhynchobothrium* sp.

1901.—Aug. 24, 1, a larva, not mature enough to admit of identification. It was obtained from a very long blastocyst from the ovary of its host. Length of blastocyst 180 mm., average diameter 2 mm. July 29, elongated blastocysts on viscera. Larva from one not far enough developed to allow even generic determination.

7. *Tetrachynchus bisulcatus* Linton.

1901.—July 29, scolex from cyst in stomach wall, under serous coat. Other cysts were opened, but no entozoa found. One liberated a yellow mass, which appeared to be a degenerate blastocyst. The interior was semifluid, with irregular masses of carbonate of lime scattered through it. The same condition existed in a cluster of cysts on the mesentery. The presence of carbonate of lime in these cysts was shown by the brisk effervescence in dilute hydrochloric acid. In some cases the calcareous material, instead of being scattered through a fluid in granules, was aggregated into a mass which filled the greater part of the cyst. Other scolices obtained from another fish examined later on this same date. July 30, scolices from cysts in stomach wall. July 31, few. Aug. 6, few.

1902.—July 18, 23, 25, Aug. 1, 15, few on each date; cysts in stomach wall.

### TREMATODES.

8. *Distomum monticellii* Linton (?).

1901.—July 30, 1, incomplete specimen closely agreeing with this species. Oral sucker 0.10 mm., ventral sucker 0.32 mm.; ova 24 by 14 microns. July 31, 3, pale orange; ventral sucker more than three times diameter of oral; ova 27 by 14 microns, cirrus spinose, one of the vitellaria distinctly three-lobed, but not situated far back of ventral sucker. Aug. 6, 3 small distomes, which agree with this species in proportions and character of vitellaria, but the ova are smaller than in any appendiculate I have hitherto seen. This latter feature is true also of a large distome which was associated with these (see No. 9, below). Dimensions in millimeters: Length 2.8; diameter of oral sucker 0.11, ventral sucker 0.46; ova 0.014 and 0.010 in the two principal diameters.

9. *Distomum tornatum* Rudolphi. [Fig. 156.]

1901.—Aug. 6, 1; vitellaria tubular. Dimensions, in millimeters: Length 10, breadth 2; transverse diameter of oral sucker 0.32, of ventral sucker 0.84; ova 0.015 and 0.010 in the two principal diameters. See No. 8, above.

10. *Distomum vitellosum* Linton.

1901.—July 29, numerous; of great variety of size and shape, e. g., length 1.12, breadth 0.4; and length 3.6. The ova do not vary much from 60 by 40 microns in the two principal diameters. Fimbriated borders of ventral sucker very prominent. When placed in fresh water these distomes become rigid, the body cylindrical, and the neck reflected until it stands nearly at right angles to the body. The neck, even in the larger specimens, is always very short. Fifty or more were obtained from a third fish which was examined later on this date.. Most of these were elongated, 5 mm. and more in length, with prominent ventral sucker and reflected neck. The distomes in this lot were rather delicate and fragile. There were a very considerable variety of shapes. Indeed, if they were not seen in such large numbers together they might very easily help to increase the confusion which exists at the present time in the classification of the distomes. July 30, large numbers and great variety of size and shape. July 31, few, large (4.25 mm.) and fragile. Aug. 1, numerous. Aug. 6, numerous, very variable in shape and size, most of them somewhat macerated. Aug. 20, 150 from one host. Aug. 24, numerous.

1902.—July 18, 23, 25, Aug. 1, 15, 20, usually numerous and of diverse shapes.

Dimensions, in millimeters: Length 1.12; diameter 0.15; another, length 3.92, diameter 0.4. A leading character of this species is the presence of a number of short lobes surrounding the ventral sucker, often very prominent, but in certain stages of contraction to be made out only with great difficulty. In specimens which are not in good condition these lobes can not be made out at all. Indeed, they were not noticed in the specimens upon which the original description of the species was based. The longer specimens owe their greater length principally to the extension of the body, and not to the neck, which remains short. Œsophagus distinct and of moderate length.

11. *Distomum tenue* Linton.

1901.—July 29, 3 or more; length of one 1.62 mm.; ova 93 by 52 microns.

12. *Distomum valde-inflatum* Stossich.

1902.—July 18, few; encapsuled on viscera.

13. *Distomum hispidum* Abilgaard.

1901.—Aug. 1, 2, 3.5 and 1.5 mm. in length, respectively. Spines were missing from the neck of the larger specimen, but were present in the smaller.

### **Abudefduf saxatilis**, *Cow Pilot.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1902. | | |
| July 17 | 1 (length 32 mm.) | Copepods and zoæa of crabs—no entozoa found. |

### **Chætodipterus faber**, *Porgee.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| July 11 | 1 | Contents of alimentary canal almost indistinguishable, but under the microscope fragments (for the most part spines) of annelids; the eye of a shrimp or small crab, and a number of small, sandy, oblong bodies, presumably foraminifera. No entozoa. |
| July 31 | 1 | This specimen was small, 100 mm. long. The alimentary canal contained sand, in which setæ of annelids and tests of diatoms were recognized. |
| August 6 | 1 | Small specimen. The only recognizable material was a gorgonian coral (*Leptogorgia*), orange colored, and with slender, straight spicules. |

#### TREMATODES.

1. *Distomum inconstans* sp. nov. (Figs. 183–187.)

These are small distomes of very diverse shape, some being nearly circular or squarish in outline, while others are long-oval or fusiform. The short or contracted specimens are yellowish and densely clothed anteriorly with low, flat, rounded spines. The elongated specimens are translucent, bluish white, with spines very scanty and difficult to make out. Suckers about equal, sometimes one, sometimes the other being the larger. The pharynx, not of constant shape, is a little longer than broad, and in specimens which are not too strongly contracted is separated from the anterior sucker by a distance rather less than the length of the pharynx. There is a distinct œsophagus, and the intestinal rami are simple and extend nearly to the posterior end of the body. Testes subglobular, lateral, about the middle of the length of the body; in the specimens studied 6 were counted on the left side and 4 on the right. The cirrus passes to the left of the ventral sucker, opening in front and a little to the left of it. Its position, however, varies with the state of contraction. In some cases the cirrus pouch is posterior to the ventral sucker; in others it is to the left, and in yet others in front of the ventral sucker. The prostate gland and seminal vesicle are both included in the cirrus pouch. The ovary is median, situated between the two groups of testes. It is lobed, and is about the same size as a single testis. The vitellaria are very abundant, filling the posterior and lateral regions of the body, and extend as far forward as the origin of the intestinal rami, or even to the pharynx, covering and obscuring the other organs. Folds of the uterus lie in the median line both in front of and behind the testes, continuing on the left side of the ventral sucker, lateral to the cirrus, to the genital aperture.

Dimensions, in millimeters, life: Lengths of two short-oval specimens 0.7 and 1.15; breadths of same 0.45 and 0.65; diameter of oral sucker 0.18, of ventral sucker 0.2; ova 0.06 by 0.04.

In another lot: Longest specimen 2.1, breadth 0.77; average length about 1.25, and breadth 0.8. Diameters of oral suckers in three specimens 0.17, 0.18, and 0.16, respectively; diameters of the corresponding ventral suckers 0.18, 0.16, and 0.17, respectively.

1901.—July 31, 9, small, short-oval. Aug. 6, numerous, of great variety of shapes.

### **Monacanthus hispidus**, *File-fish.*

| Date. | Number of fish examined. | Food notes |
|---|---|---|
| 1901. | | |
| July 31 | 1 (small) | Small amphipods, fragments of other small crustacea, sea weed; no entozoa |
| 1902. | | |
| July 7 | 11 (small) | Shrimp, annelids. |
| July 8 | 9 (small) | Hermit crabs, amphipods, small lamellibranchs, sea weed. |
| July 14 | 13 (small) | Small piece of intestine examined with compound microscope and found to be packed with a bryozoan (*Bugula*). |
| July 16 | 2 (small) | Large quantities of *Bugula* sp. and amphipods, also copepods, a few fragments of lamellibranch shells, a few egg cases of a gasteropod; and a little sand. |
| July 18 | 6 (small) | *Bugula*, gastropod eggs, small lamellibranch, *Crepidula* and three other small gastropods. |
| July 19 | 3 (small) | Mainly *Bugula*. |
| July 21 | do | Small lamellibranchs and amphipods. |
| July 23 | 2 (small) | Small crustacea, several species of lamellibranchs, and bryozoa; no entozoa. |
| July 25 | 1 (small) | Food not noted. |
| July 26 | 3 (small) | Do. |
| July 29 | do | Amphipods and small gastropods (*Olivia*, etc.). |
| August 11 | 1 (small) | Amphipods, small lamellibranchs, and bryozoa. |
| August 20 | do | Amphipods, small sea urchins, sand; no entozoa. |

#### ACANTHOCEPHALA.

1. *Echinorhynchus pristis* Rudolphi.

1902.—July 25, 1, male.

#### CESTODES.

2. *Scolex polymorphus* Rudolphi.

1902.—July 8, few. July 14, numerous, forms with one costa on bothria. July 18, few. July 19, several. July 21, 23, few, forms with two costæ. July 25, few, minute. July 26, few, forms with two costæ. Aug. 11; 1.

3. *Cysts.*

1902.—July 7, small cysts on viscera; no larvæ found.

#### TREMATODES.

4. *Distomum vitellosum* Linton.

1902.—July 8, 1.

5. *Distomum valde-inflatum* Stossich.

1902.—July 16, 1, in capsule on viscera. Dimensions, life, compressed, in millimeters: Diameter of capsule 1.05; length of distome 0.85; diameter, anterior 0.21, posterior 0.45 (nearly uniform from ventral sucker back); diameter of oral sucker 0.18, of ventral sucker 0.19. Thirty-four oral spines, double row dorsal and ventral, single row lateral. This arrangement of hooks is like that of *Distomum imparispine* from *Rachycentron canadus.* July 18, 1.

6. *Cercariæ.*

1902.—July 8, 3 redia-like bodies from body cavity; shape reniform with a few oil globules in the hilus; several individual aggregations of cells which are probably young *Cercariæ.* Dimensions in millimeters: Redia, length 1.05; breadth 0.45; cercaria from 0.07 to 0.15 in length.

### **Alutera schœpfii**, *File-fish.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| July 16 | 1 (100 mm.) | Alimentary canal throughout its length crowded with bryozoa. |
| August 8 | 1 (small) | Shrimp, amphipod, and sea lettuce. |

No entozoa were found save one small cyst with nothing in it that could be identified.

**Spheroides maculatus**, *Puffer*.

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| July 31 | 5 | A great variety of mollusk shells, broken, both bivalves (*Pecten*, *Anomia*, *Solenomya*, *Venus*) and univalves. Also barnacles (*Balanus*); bits of worm tubes made of sand and pieces of shell; fragments of tests of sea urchin (*Moira atropos*) and small spines of same; sponge. |
| August 1 | 4 (small) | Food practically the same as in foregoing. Fragments of tests and loose spines of the *Moira* sea urchin, *Moira*, especially abundant. |
| 1902. | | |
| July 7 | 1 (150 mm.) | *Arbacia* |
| August 11 | 1 | Crab, shrimp, barnacle (*Balanus*), annelids, sea urchin (*Moira*), watermelon seed. |
| August 15 | 1 | Operculum of gastropod, sea urchin (*Moira*). |
| August 20 | 1 | Crab, shrimp, amphipod, annelid, bryozoa, seaweed. |
| August 23 | 2 | Ascidian, oyster and other lamellibranchs, *Arbacia*. |

NEMATODES.

1. *Ascaris, immature.*

Type with diverticula on œsophagus and intestine.

1902.—July 7, 2, the larger 12 mm. in length, with characteristic jaws of *Ascaris;* post-anal region of smaller specimen rather more slender than the other; diverticulum of œsophagus with a series of punctate dots along its axis. Aug. 11, few. In this lot the jaws were sufficiently developed to show apparent identity of the species with *A. habena*. The diverticula of œsophagus and intestine also agree with that species.

CESTODES.

2. *Tetrarhynchus bisulcatus* Linton.

1902.—Aug. 11, 1 scolex from viscera.

TREMATODES.

3. *Distomum vibex* Linton. [Fig. 188.]

1901.—July 31, 1. Aug. 1, 1; color blood red. The flattened specimen measured 6 mm. in length and 3 mm. in greatest breadth. A reexamination of sections of specimens of this species showed the presence of diverticula of the intestines prolonged anteriorly parallel to the pharynx, as shown in sketch of this specimen.

1902.—Aug. 11, 2 large, 14 small; reddish-brown, diverticula of intestines noted in flattened specimen. Aug. 15, 1.

4. *Distomum* sp. [Fig. 165.]

This distome is the same as that described in my Trematode Parasites of Fish, Proceedings U. S. National Museum, vol. XX, pp. 537–538, pl. LIII, figs. 1, 2. Same as No. 4 under *Siphostoma fuscum*, and No. 13 under *Cynoscion regalis*.

Squarish-oblong, thick, white. Dimensions in millimeters of living specimen, slightly compressed: Length 1.27; breadth through anterior sucker 0.3, through ventral sucker 0.4, maximum breadth 0.61, near posterior end 0.45; transverse diameter of oral sucker 0.16, of pharynx 0.13, of ventral sucker 0.16; ova 0.07 by 0.05.

1902.—Aug. 15, 3. Aug. 20, 12. Aug. 23, 8.

5. *Gasterostomum gracilescens* Rudolphi.

1901.—Aug. 1, 1. This is identical with the species from the gar (*Tylosurus marinus*) collected on the same date. It is of course possible that this specimen came from that lot. Since, however, great care has been exercised to prevent the mingling of material from specifically different hosts, I do not think it is likely to have chanced on this occasion.

## **Chilomycterus schœpfi**, *Rabbit Fish.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1902. | | |
| July 5 | 1 (125 mm.) | Principally small mollusk shells, both gasteropods and lamellibranchs, among which a small *Crepidula* was abundant; shells more or less broken. |
| July 8 | 1 | Large numbers of broken lamellibranch shells and small gastropods. The latter, for the most part, harbored hermit crabs. |
| July 22 | 1 | Same as above. |
| August 13 | 1 | Same as above; small oyster shells, young *Cardium*, *Ilyanassa*, and claw of crab noted. |
| August 16 | 1 | Fish, crab, lamellibranchs, and gastropods and seaweed. |
| August 26 | 1 | Gastropods and lamellibranchs, several species; also bryozoa and an isopod. |

### NEMATODES.

1. *Ascaris neglecta* Leidy.

1902.—July 8, 1, female. Body wall of living worm transparent, faintly yellow by transmitted light, vascular; intestine broad, yellowish; ovary darker; intestine and œsophagus each with a slender diverticulum. Aug. 16, 2.

### TREMATODES.

2. *Distomum* sp. [Fig. 208.]

1902.—July 5, 2, small, white, subspherical; immature. Intestines voluminous, the bifurcation ventral to posterior half of pharynx, contents of intestine granular. Whole body appears to be filled with granular material when moderately compressed. Dimensions, life, moderately compressed, in millimeters: Length 1.06, breadth 0.82; diameter of oral sucker 0.15, ventral sucker 0.17; pharynx, length 0.105, breadth 0.120; orifice of oral sucker, length 0.06, breadth 0.09; ventral sucker, length 0.06, breadth 0.06. Both suckers circular.

1902.—July 22, 1; apparently adult of this species. Dimensions of living specimen in millimeters: Length 2.25, breadth 1.5; diameter, of oral sucker 0.33, of pharynx 0.16, of ventral sucker 0.38; ova 0.072 by 0.043. Aug. 16; 1. This was at first taken to be a *Monostomum*, the ventral sucker for some reason being difficult to make out. The diminsions agree with those of the one found on July 22. Aug. 26; 3. The body of these specimens is squarish, truncate in front, the oral sucker being sometimes retracted. Testes two, rather large, subspherical near posterior, and in all but one so close together as to appear to be but one. Vitellaria abundant, posterior, lateral and peripheral to œsophagus; ovary in front of testes, dorsal.

Unfortunately the anatomy of these worms is not distinctly shown in the preserved specimens. In one the genital aperture appeared to be a little in front of the ventral sucker to the left of the median line, but was not made out with absolute certainty. In another the cirrus appeared to make a sharp turn dorso-caudad then mediad to open in the ventral sucker as in *Monostomum.*

Two specimens were cut into serial sections, one transverse, the other sagittal, but the material having been in poor condition when first collected, even with this aid the anatomy was poorly shown.

In all the specimens the ventral sucker is less distinct than the oral, and the pharynx in all is very distinct.

### COPEPODS.

3. *Chondracanthus* sp.

These interesting forms, along with other parasitic copepods collected at Beaufort, have been referred to Prof. C. B. Wilson. These were found on the gills, fins, ventral surface of body, and under the eyes of their hosts. At the points of attachment the skin was white and opaque, the patches looking somewhat like sporozoa cysts. Length 5.5 mm; length of egg-chains 3 mm. Some of the ova contained nauplii.

1902.—July 5, 37. July 22, 23. Aug. 13, numerous. Aug. 16, 1.

## **Prionotus scitulus**, *Sea Robin.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| August 1 | 5 (small) | Numerous small mollusks (*Bulla*, *Solenomya*, etc.) and crustacea (ostracoids, copepods, cumacea, etc.). |
| August 16 | 1 (small) | Shrimp, small univalve mollusks (young *Olivia*). |
| 1902. | | |
| August 1 | 1 | Crabs, shrimp, small gastropods. |
| August 15 | 6 | Fish, crabs, shrimp, small gastropods. |

NEMATODES.

1. *Immature nematodes* (*Ascaris* sp.).

1901.—Aug. 1, few, on viscera; type with diverticula on both œsophagus and intestine.

CESTODES.

2. *Rhynchobothrium* sp.

Type with oval cysts, short larva, and relatively long hooks. Aug. 1, 1902; 1.

3. *Tetrarhynchus bisulcatus* Linton.

1901.—Aug. 1 and 16, few, encysted in stomach wall.

1902.—Aug. 15, cysts in stomach wall.

TREMATODES.

4. *Distomum appendiculatum* Rudolphi.

1902.—Aug. 15, 1.

5. *Distomum vitellosum* Linton.

1902.—Aug. 15, 1, not in good condition.

6. *Distomum* sp. [Fig. 157.]

1902.—Aug. 1, 1, not in good condition. Dimensions, in millimeters: Length 1.65; diameter of oral sucker 0.09, of pharynx 0.05, of ventral sucker 0.2; ova 0.032 by 0.016.

## **Prionotus tribulus**, *Sea Robin.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| July 8 | 2 | Fish and crabs. |
| July 18 | 2 | Fiddler crabs. |
| July 31 | 2 (small) | Otoliths of small fish, crabs, shrimp. |
| August 1 | 4 (small) | Crabs and shrimp. |
| August 16 | 6 (small) | Fish and crabs. |
| 1902. | | |
| July 8 | 1 | Crustacea; no entozoa. |
| July 11 | 5 (150 mm.) | Crabs, shrimp. |
| July 23 | 1 | Lamellibranchs, young *Limulus*, small crustacea; no entozoa. |
| July 21 | 1 | Crabs, shrimp. |
| August 8 | 3 | Shrimp, amphipods, copepods, etc., annelids. |
| August 13 | 2 | Shrimp. |
| August 18 | 1 | Shrimp, lamellibranchs. |
| August 20 | 2 | Shrimp, sea urchin. |

ACANTHOCEPHALA.

1. *Echinorhynchus sagittifer* Linton.

1901.—July 31 and Aug. 16, 1 on former date and 2 on the latter, on serous coat of viscera inclosed in thin membranous cyst.

NEMATODES.

2. *Immature nematodes.*

1901.—Aug. 1, few, not in good condition.

1902.—Aug. 13, few, type with diverticula on œsophagus and intestine.

CESTODES.

3. *Scolex polymorphus* Rudolphi.

1902.—Aug. 20, few, small.

4. *Rhynchobothrium* sp.

1901.—July 8 and 18, numerous, encysted in stomach wall. They agree with the form figured in Larval Cestodes of Fishes, Proceedings of U. S. National Museum, vol. XIX, pl. LXIII, figs. 3–5.

1902.—July 11, few, type with small oval cysts on viscera, short larva, and relatively long hooks.

5. *Tetrarhynchus bisulcatus* Linton.

1901.—July 31, Aug. 16, few, encysted in stomach wall.

1902.—July 11, few. Aug. 12, 3.

TREMATODES.

6. *Distomum appendiculatum* Rudolphi.

1901.—Aug. 1, 2, cylindrical, with fine, regular, transverse wrinkles, under high magnification resembling annulations; position and general character of testes, ovary, and vitellaria agree with this species. Dimensions, in millimeters, life: Length, not including appendix, 0.88; diameter of oral sucker 0.069; pharynx, length 0.045, breadth 0.034; ventral sucker, length 0.12, breadth 0.13; diameter, anterior 0.12, middle 0.49; ova 0.028 by 0.014.

1902.—Aug. 8, 1. [Fig. 153.] Annulate, with sharply serrate outlines in life. Testes 2, close behind ventral sucker, diagonally placed. Seminal receptacle between testes and ventral sucker. prostate, elongated, and conspicuous. Ovary behind testes a distance equal to its own diameter; Vitellaria 2, close to posterior edge of ovary, not lobed; uterus voluminous. Length, in millimeters, 1.12; maximum diameter 0.3; diameter of oral sucker 0.06, of pharynx 0.03, of ventral sucker 0.15; ova 0.025 by 0.014. Aug. 20, 4, small.

7. *Distomum monticellii* Linton.

1901.—Aug. 16, 1. Dimensions, in millimeters, life, compressed: Length 3.29, breadth 0.61; diameter of oral sucker 0.17, of ventral sucker 0.38, of pharnyx 0.08; ovum 24 by 14 microns.

8. *Distomum vitellosum* Linton.

1901.—July 8, 31, 1 on each date.

1902.—Aug. 8, 1. This specimen was remarkable for the elongation of the ventral sucker on a pedicel; the fimbriated border around the ventral sucker was also unusually prominent. The specimen had no ova and appeared to be immature. Aug. 18, 2. These were of very different appearance, the one from the other. One was oval and looked at first like *D. pyriforme*. The other at first had somewhat the habit of body of *D. appendiculatum*. This diversity of form is not unusual in this species. Specimens in the same lot are often found which bear but little resemblance to each other, but which, after flattening under a cover glass in the presence of gentle heat, expand into identical forms.

COPEPOD PARASITES.

9. *Lernanthropus* sp. From gills.

1902.—Aug. 18, 2, females with long egg chains.

**Opsanus tau,** *Toad-fish.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| July 9 | 1 (small) | Fragments of crustacea. |
| July 16 | 1 | Fish and shells of gastropods (*Ilyanassa*, *Urosalpynx*, *Achirus* (?), *Truttia*, etc.). |
| July 18 | 2 | Small crabs. |
| July 24 | 1 (small) | Crabs. |
| July 26 | 1 | Crabs and other crustacea. |
| August 2 | 2 | (1) *Ilyanassa* (several), *Pecten*, sea anemone, small crab, piece of bark, and large pebble. (2) Pieces of test and spines of *Arbacia* (a large quantity). These fish were taken near the wharf at the laboratory. No entozoa were found in the alimentary canal of the second. It would appear that the diet of sea urchins had in this case acted as an anthelmintic. |
| Do | 4 | This lot, which was taken at the breakwater near Fort Macon, contained only crabs in the alimentary canals. |
| August 3 | 2 | Crabs and gastropods (*Ilyanassa* and *Urosalpynx*). |
| August 6 | 4 | Fish, crabs, and gastropods. |
| August 8 | 1 | Lamellibranch mollusks. |
| August 9 | 2 | Crustacea (hermit crabs). |
| August 12 | 6 | Fish and crustacea. |
| August 13 | 9 | Crabs, gastropods, and sea urchin (*Arbacia*). |
| August 16 | 1 | Fish and crabs. |
| August 20 | 2 | Fish and mollusks. |
| August 21 | 1 | Stomach empty; material in intestine completely digested. |
| August 22 | 2 | Fish and crabs. |
| August 23 | 2 | Fish. |
| August 27 | 5 | Fish, gastropod and lamellibranch mollusks, small stone crabs. |
| August 29 | 1 | Fish, lamellibranch mollusks, spider crabs, and other crabs. |
| August 30 | 3 | Spider crabs and other crabs, gastropod mollusks. |
| 1902. | | |
| July 14 | 2 | Hermit crabs and shrimp. |
| July 16 | 9 | Crabs, gastropod shells (most of them with hermit crabs), annelids. |
| July 19 | 4 | Crabs, shells, shrimp. |
| July 21 | 2 | Crabs, shells. |
| July 22 | 4 | Crabs, shells, shrimp, *Pecten*. |
| July 26 | 4 | Shrimp. |
| July 28 | 1 | Not noted. |
| July 29 | 4 | Crabs. |
| July 30 | 4 | Crabs (fiddler, stone, and hermit), shrimp. |
| July 31 | 3 | Shrimp. |
| August 4 | 11 | Shrimp, crabs, gastropods, lamellibranchs, eel grass. |
| August 7 | 1 (large) | Alimentary canal empty. |
| August 8 | 1 | Crabs, shrimp, sea urchin (*Arbacia*). |
| August 11 | 5 | Crabs, shrimp, gastropods. |
| August 16 | 1 | Stone crab, shrimp. |
| August 18 | 4 | Crabs, gastropods. |
| August 19 | 8 | Stone crabs, hermit crabs, shrimp, gastropod shells (*Ilyanassa*, *Urosalpynx*), *Arbacia* (spines and test), eel grass. |
| August 20 | 9 | Hermit crabs, spider crabs, etc., fish. |
| August 21 | 2 | Crabs. |
| August 22 | 1 | Not noted. |
| August 23 | 1 | Alimentary canal empty. |
| August 26 | 2 | Spider crabs. |

### NEMATODES.

1. *Ascaris habena* Linton.

1901.—July 9, 2, young. July 18, 1, male, length 15 mm. July 24, 1, female; ova not mature, length 20 mm. July 26, 1, female; ova 65 by 45 microns. Aug. 2, 5, all males; later on same date, 2 adults, 1 male and 1 female; also 2 immature nematodes. The latter had diverticula to œsophagus and intestine. Aug. 3, 6 in one, 2 in the other. Aug. 6, few, only 1 adult female in the lot; ova segmenting. Aug. 8, 1. Aug. 9, few, young and adult. Aug. 2, 6. Aug. 13, 25, adult males and females, and immature. Aug. 21, 2 large and 3 small. Aug. 22, 12, all from one of the fish, adult and immature. The diverticula of an immature form with rudimentary jaws were compared with those of a young worm with the characteristic jaws of this species and found to agree. It would seem that a great many of the immature nematodes recorded from a variety of hosts are young of this species. Aug. 23, few, small. Aug. 27, 6. Aug. 29, 5, female. Aug. 30, 6, young.

1902.—July 14, 1, male. July 16, 12, adult. July 19, 1, female. July 21, 2, females, large and small, stouter than usual, intestine greenish. July 26, 6. July 29, several, ova segmenting. July 30, few. July 31, few. Aug. 4, several. Aug. 7, 1. Aug. 8, several. Aug. 11, 16, 18, several on each date, large and small. Aug. 19, numerous, large and small. Aug. 20, few. Aug. 21, few, small. Aug. 23, 1, female.

Usually in the intestine near the pylorus, not infrequently in the stomach.

2. *Immature nematodes.*

Probably for the most part young of *Ascaris habena.*

1901.—July 16, few, from alimentary canal; diverticula of intestine and œsophagus, as in many different hosts; the most usual type; agreeing in this particular with *A. habena.* Length 15 mm. July 26, several. Aug. 2, 2. Aug. 6, few. Aug. 12, few; one of these immature worms, after lying for twenty-four hours in water, shed the cuticular investment and revealed the characteristic head of *Ascaris.* Aug. 20, numerous, encysted in intestinal wall. Some of the cysts were without nematodes and filled with waxy, degenerate tissue. Aug. 22, a yellowish cyst with calcareous nucleus, agreeing in general appearance with those of preceding date. [Fig. 27.] The diverticulum of the intestine was observed to extend halfway to the mouth, while the diverticulum of the œsophagus was longer than the œsophagus. [Fig. 28.]

1902.—July 14, 2; length 8 mm. July 16, numerous. July 21, several, different sizes. Aug. 7, several, some encysted and surrounded by yellowish, granular material; several, encysted, with waxy secretion. Aug. 18, several. Aug. 20, several.

### CESTODES.

3. *Scolex polymorphus* Rudolphi. [Figs. 76–78.]

1901.—July 9, numerous in intestine and larger than I have been accustomed to see them in this situation. Each bothrium was crossed by two distinct ribs (costæ). Anteriorly there was a distinct muscular organ like a globular pharynx, which doubtless functions as a sucker. The appearance of this structure was not unlike the mouth and pharynx of a trematode. July 16, several, active; red pigment present in neck, and costæ on the bothria. When disturbed some retracted the bothria until nearly inverted. The last part to disappear is the posterior edge of the bothrium. July 18, rather numerous in alimentary canal; very active; two costæ on each bothrium. One was noticed which, in addition to the two costæ, carried an anterior loculus on each bothrium. It is probably a young *Calliobothrium.* Another had the characteristic bothria of *Echeneibothrium* and *Rhinebothrium.* Its prominent muscular proboscis (myzorhynchus), if retained in the adult, would place it in the former genus. This free larva was very much smaller than the larval *Rhinebothrium,* which was encysted on the viscera, and abundant in this lot. (See No. 4, below.) Length of bothria, in this larva, about the same as that of its associates which have but two ribs on the bothria, instead of the numerous ribs of this one, viz., 0.2 mm. Corresponding forms released from blastocysts (No. 4, below) measured about 0.7 mm. when at rest. July 26, numerous; large, two costæ developed on bothria and two pigment patches in neck. Same found on three following dates: Aug. 2, few; in both lots on this date. Aug. 6, 23, several. Aug. 27, numerous; in intestine small; also in cystic duct, larger. Aug. 29, numerous, from intestine. The largest had bothria which resembled those of *Calliobothrium* and *Acanthobothrium,* but without hooks. Some of the smaller also had costæ faintly outlined on the bothria. Aug. 30, few.

1902.—July 14, rather numerous in intestine, with costæ on bothria but no red pigment. July 16, different stages of development, the longest with two costæ. July 19, numerous. July 21, two sizes, the smaller about one-tenth the length of the larger, one curious abnormal form with three-forked posterior end, very changeable. [Fig. 78.] July 22, several. July 26, few. July 28, few. July 30 and 31, several, large and small. Aug. 4, numerous, some comparatively large. Aug. 7, numerous, small, with two costæ. Aug. 11, rather numerous. Aug. 16, few. Aug. 19, specimens with red pigment and two costæ. Aug. 30, several, red pigment, two costæ, one specimen noted with rudimentary hooks (*Calliobothrium* or *Acanthobothrium*). Aug. 21, large, two red pigment patches, rudimentary hooks. Aug. 22, rather numerous, small. Aug. 26, several, of good size.

4. *Rhinebothrium* sp. [Figs. 59–74.]

These are larval forms near *R. flexile.* They were found in 19 out of 20 lots of fish examined during the season of 1901. The dates on which they were found are included between July 9 and Aug. 30.

These larvæ are found on the viscera generally, but especially on or near, occasionally in, the liver, and in the mesentery. Early in the season of 1901 I was struck by the large numbers of blastocysts clustered together in comparatively small compass. [Fig. 59.] The frequent recurrence of these clusters led me to examine them with some care with the hope that the reproduction of successive generations of blastocysts by some process of budding could be demonstrated. The cysts are, as a rule, comparatively thin-walled. The blastocysts are club shape, the part representing the handle of the club being usually much, often enormously, elongated. [Fig. 62.]

Dimensions of one, in millimeters, life: Enlarged anterior portion 3 in length and 1 in diameter; slender posterior portion 9 in length and 0.1 in diameter. This specimen enlarged slightly into a rounded knob at the extreme posterior end, a characteristic feature of these blastocysts and possibly having some bearing on the method of development of new blastocysts.

The larva is situated in the enlarged anterior portion. When a blastocyst is subjected to slight pressure the larva may be seen through the transparent walls at the anterior end of the enlarged portion. The parenchyma of the blastocyst contains numerous calcareous bodies, which often are rather irregularly shaped. Upon continued pressure, especially if aided with needle points or similar tool, the larva may be liberated from the blastocyst [fig. 64]. When so liberated it separates from the blastocyst. Even when separated entirely from its blastocyst its bothria often remain retracted. They may be seen in some instances protruding from the anterior end of the scolex. What is thus seen is of course the posterior edges of the bothria, since in retracting the head it is really inverted and the last part of the bothria to disappear is the posterior border. Usually the bothria may be made to appear by suitable manipulation, although I did not succeed in getting them to expand freely after they had been thus unsheathed. The bothria are leaf-like and have the characteristic loculi of the genus *Rhinebothrium.* The number of loculi on each bothrium was found in one favorable example to be as represented in fig. 71; that is, 27 on each side with an odd one at each end, or 56 in all. One character possessed by these larvæ, which would at first glance ally them with *Echeneibothrium* rather than *Rhinebothrium,* is a terminal aperture into which the bothria may be retracted. This is a character, however, which is possessed by cestodes generally during larval stages of the scolex. Doubtless the larvæ of the genera *Rhinebothrium* and *Echeneibothrium* will be found to be much alike. (See above under *Scolex polymorphus.*)

It is not unusual to find two or more blastocysts each with a larva inclosed in the same cyst. Attempts to demonstrate the vital connection between two blastocysts each containing a larva by means of sections have not been successful. A cyst containing two blastocysts each containing a well-developed scolex was sectioned and the sections mounted serially. The long tail-like portions appeared upon the first study of the sections to be continuous with each other, which would have amounted to a demonstration of budding. A careful reconstruction of the sections, however, showed that the two blastocysts were independent of each other.

An interesting case in this connection, although demonstrating nothing, is shown in fig. 66, sketched from a cyst which was stained and mounted in balsam. The cyst is small, 1.41 mm. in length, shaped like a dumb-bell, completely invested with a connective tissue cyst, but with undoubted continuity of the material of the blastocyst. Further dimensions of blastocyst, in millimeters: Length, of larger end 0.45, of smaller end 0.21, of connecting part 0.65; diameter, of larger end 0.30, of smaller end 0.19, of connecting part 0.09, in the middle, constricted to 0.027 and 0.021 near the larger and smaller ends, respectively.

1901.—July 9, numerous cysts on liver, stomach, intestine and mesentery. July 16 and 18, numerous on viscera. In one of the fish the long tails of the blastocysts were felted together in a mass on the mesentery. July 26, very numerous, in a cluster 20 mm. square and containing several hundred cysts on the mesentery. One cyst in this lot contained three blastocysts, each with a larva. Aug. 2, numerous on liver, stomach, and intestine, some in clusters. Aug. 3; numerous in cluster in one of the fish, few on the liver in the other. Aug. 6 and 8, numerous, clustered. Aug. 9, numerous in clustered cysts on serous coat of rectum. Aug. 12, 13, 16, 20, 21, 22, 23, numerous clusters of cysts on viscera on each date. Aug. 27, clusters of cysts on rectum, in and on liver, cysts in stomach wall. Aug. 29, numerous clusters of cysts on liver and other viscera. Aug. 30, few, cysts on viscera.

Clusters of cysts containing blastocysts and larvæ on viscera.

1902.—July 14, 19, numerous. July 21, 22, several, also elongated cysts with blastocysts, but no larvæ [fig. 84]. July 26, 28, numerous. July 29, 30, 31, several. Aug. 4, numerous. Aug. 7, 8, not numerous. Aug. 11, 12, 16, 18, numerous. Aug. 19, numerous, much waxy secretion associated with the clusters. Aug. 20, 21, numerous clusters. Aug. 23, 26, small clusters of cysts.

See No. 2 under *Siphostoma fuscum.*

5. *Rhynchobothrium tumidulum* Linton.

1901.—July 26, from cysts associated with No. 4; larvæ remaining attached to blastocysts; contractile bulbs long and slender with red pigment spot at anterior end of each, length 0.56 mm.; diameter 0.07 mm.; proboscides not seen extended. Aug. 27, from cysts on viscera.

1902.—Aug. 16, 1, cyst on viscera.

6. *Otobothrium crenacolle* Linton.

1901.—Aug. 30, encysted, few.

7. *Tetrarhynchus bisulcatus* Linton.

1901.—Aug. 20, 1 scolex from cyst. Hooks blunt; neck thicker than head.

1902.—July 21, 1, encysted in stomach wall.

TREMATODES.

8. *Distomum vitellosum* Linton.

1902.—July 16, 3. July 28, 2, immature. Aug. 16, few. Aug. 18, 5. Aug. 19, few. In some the testes were lobed, best seen under moderate pressure; in others they were not lobed.

9. *Distomum valde-inflatum* Stossich.

1901.—July 16, globular cysts encapsuled on viscera containing immature distome with double circle of oral spines, about 24 in each circle; length of distome 1.96 mm. July 26, Aug. 2, 6, 23, in globular cysts on each date, associated with No. 4. Dimensions of a distome collected on Aug. 2, in millimeters: Length 2.38; diameter, at anterior end 0.28, at ventral sucker 0.53, near posterior end 0.76, of anterior sucker 0.18, of ventral sucker 0.25, of pharynx 0.2; length of oral spines 0.048. Aug. 30, few, in globular, pediceled cysts on viscera. It is to be noted that this species rests on immature forms and is doubtless identical with some adult form—e. g., *D. dentatum.* In globular cysts on viscera associated with No. 4, frequently with yellowish secretions.

1902.—July 14, few. July 16, numerous. July 19, 21, several. July 26, 29, 31, few on each date. Aug. 16, numerous. Aug. 21, few. Aug. 23, 1. Aug. 26, few.

10. *Distomum aduncum* sp. nov. [Figs. 195–197.]

Small and minutely spinose, ovate, greatest diameter near posterior end, whence it tapers to the anterior end; posterior end broadly rounded. Oral sucker larger than ventral; pharynx a little longer than wide, remote from the oral sucker; œsophagus long; intestinal rami simple, thick-walled, short, extending but a short distance beyond the ventral sucker, which is situated a little behind the middle of the body. Testes two, lateral, a short distance behind the ventral sucker. The very muscular base of the cirrus pouch lies on the right side of the ventral sucker. Four stout hooks were seen at the anterior end of this muscular organ [fig. 197*h*] which doubtless make a grappling copulatory armature at the base of the cirrus when everted. The cirrus was not seen everted; it appeared to arch from the muscular organ in front of the ventral sucker to terminate in the genital aperture. The genital aperture is a very conspicuous organ in this species. It lies close beside the ventral sucker on the right side, and is specialized into a muscular sucker, slightly larger than the ventral sucker and of similar appearance. Ovary subglobular, adjacent to anterior edge of the left testis and to the genital sucker. The vitellaria are lateral lobed masses lying immediately behind the testes. The folds of the uterus are in the post-acetabular region, both behind and among the testes and vitellaria; ova numerous and small.

Dimensions in millimeters of a specimen in formalin: Length 0.7; greatest breadth 0.35; transverse diameter of oral sucker 0.07; pharynx, length 0.04, breadth 0.03; vedtral sucker, length 0.048, breadth 0.041; genital aperture, length 0.061, breadth 0.058; ova, some variation in size, average of best-formed ones 0.020 by 0.010. The largest specimen measured 0.87 mm. in length and 0.38 mm. in breadth. A specimen which was not observed until after it had been killed was arcuate, the ventral surface being concave from side to side and from front to rear.

1901.—Aug. 27, 4.

1902.—Aug. 8, 11, 16, 1 on each date.

A small specimen, apparently identical with the specimens above described, was found on Aug. 15, 1902, in the sand snipe (*Calidris arenaria*).

11. *Distomum* (?) sp. [Fig. 215.]

1901.—Aug. 27, 1, pale red, thick, dorsal surface roughly nodular. In lateral view about five papillæ visible on the side, back of middle. When the worm was placed on the slide it lay on its side, in which position it was studied. While it was under the cover glass a white excretion was forced from the posterior end in a slender thread, probably from the excretory vessel. Dimensions, in millimeters, side view: Length 2.8; diameter, anterior 0.42, middle 0.70, posterior 0.42.

12. *Distomum* sp.

A small fusiform distome. Aug. 8, 1902; 1. Dimensions, life, in millimeters: Length 0.7; breadth, at anterior end 0.09, at ventral sucker, near middle and maximum, 0.3, tapering to posterior end; oral sucker, length 0.07, breadth 0.06; pharynx, length 0.06, breadth 0.05; ventral sucker, length 0.12, breadth 0.16; ova 0.029 by 0.018.

This species resembles *D. bothryophoron.*

13. *Distomum* sp. [Figs. 167, 205.]

A small, oval, minutely spinose distome resembling *D. pyriforme* Linton, but with smaller, more numerous and distinctly fusiform ova. Dimensions, life, in millimeters: Length 0.5; breadth 0.3; diameter, of oral sucker 0.09, of pharynx 0.04, of ventral sucker 0.06; ova 0.029 by 0.018.

In fig. 167 the specimen is compressed more than in fig. 205.

14. *Gasterostomum gracilescens* Rudolphi. [Figs. 238, 239.]

1902.—Aug. 8, several, small, oval, very minutely spinose, immature. Dimensions, in millimeters: Length 0.6; diameter, middle and maximum 0.45; diameter of anterior sucker 0.21, of mouth 0.09.

See under *Menidia*, *Tylosurus marinus*, etc.

15. *Monostomum vinal-edwardsii* Linton. [Figs. 220–221.]

1901.—July 9, 1. July 16, 5. July 18, 5. Aug. 3, 1. Aug. 16, 8. Aug. 22, 6. Aug. 27, 8. Aug. 30; 2. The excretory vessels of the neck seen in ventral view appeared to be enlarged into oval sacs at their inner ends and terminated at the surface in minute tubes.

1902.—July 14, 11. July 16, 7. July 22, 5. July 26, 1. July 29, 4. July 30, few. Aug. 8, 5 of usual size, length 1.8 mm., breadth 1.14 mm.; 1 smaller, length 0.42 mm., breadth 0.25 mm. Aug. 11, 11. Aug. 16, 1. Aug. 18, 3. Aug. 20, 1.

### **Hypsoblennius hentz**, *Blenny.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| August 9 | 1 | Algæ of various kinds, diatoms, and sand. |
| 1902. | | |
| July 8 | 1 (small) | Seaweed, broken shells, clusters of egg capsules of small gastropod. |
| July 30 | do | Shell and sponge. |
| July 31 | do | Otoliths of small fish, seaweed, sand. |

No entozoa found.

### **Paralichthys dentatus**, *Summer Flounder.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1902. | | |
| August 1 | 1 | Food not noted. |

It is probable that some of the flounders recorded under *P. albiguttus* belong here, as they were not always examined critically. Both species of flounder are common at Beaufort, and, moreover, are very much alike.

ACANTHOCEPHALA.

1. *Echinorhynchus sagittifer* Linton.

Aug. 1; 1, immature, from mesentery.

### NEMATODES.

2. *Immature nematodes* (*Ascaris*).

   Type with diverticula on both intestine and œsophagus; 1.

3. *Immature nematode* (*Ascaris*).

   Type with elongated basal portion of œsophagus and corrugated post-anal region; 1.

### CESTODES.

4. *Rhynchobothrium* sp.

   Probably encysted stage of *R. longispine* Linton. Type from oval cysts on viscera, small larva with relatively long hooks; few.

### TREMATODES.

5. *Distomum monticellii* Linton.

   One.

6. *Distomum bothryophoron* Olsson.

   One.

7. *Distomum dentatum* Linton.

   One.

### PARASITIC COPEPODS.

8. *Lernanthropus* sp.

   One, male, same species as that found on gills of *Tylosurus marinus*.

## **Paralichthys albiguttus**, *Flounder*.

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| July 17 | 3 | Fish and mud in alimentary canal. |
| July 19 | 2 | Fragments of fish. |
| July 22 | 2 | Fish. |
| August 1 | 1 | Alimentary canal empty, except for mucus. |
| August 3 | 1 | Fish, head of mullet. |
| August 6 | 1 | Contents of alimentary tract completely digested, whitish. |
| August 8 | 1 | Shrimp. |
| August 13 | 9 | Stomachs empty, intestines with whitish chyle. |
| August 15 | 1 | Fish and shrimp. |
| August 16 | 5 (small) | Shrimp and fish. |
| August 20 | 3 | Fish. |
| August 21 | 1 | Do. |
| August 26 | 4 | Do. |
| August 27 | 1 (small) | Shrimp and sea urchin. |
| 1902. | | |
| July 7 | do | Shrimp. |
| July 8 | 3 (small, 60–75 mm.) | Shrimp, mud, and sand. |
| July 14 | 1 (small) | Shrimp and other small crustacea. |
| July 15 | do | Shrimp. |
| July 16 | do | Food completely digested. |
| July 19 | do | Small crustacea (*Caprella*, etc.). No entozoa. |
| July 22 | do | Alimentary canal empty. |
| Do | 1 (large) | Do. |
| July 23 | 1 (20 cm.) | Do. |
| July 30 | 1 (small) | Do. |
| July 31 | do | Annelids. |
| August 11 | 1 | Food completely digested. |
| August 14 | 2 | Do. |
| August 16 | 2 | Fish. |
| August 18 | 1 | Shrimp. |
| August 19 | 2 | Fish, lamellibranchs, shrimp. |
| August 20 | 2 | Fish, shell of *Urosalpynx*. |
| August 21 | 1 (small) | Shrimp and amphipods. |

### ACANTHOCEPHALA.

1. *Echinorhynchus pristis* Rudolphi.

   1902.—July 15, 1, male

2. *Echinorhynchus sagittifer* Linton.

   1901.—July 22, 1, mesentery. Aug. 8, 2. Aug. 13, 1, body cavity.

3. *Echinorhynchus* sp.

   1902.—Aug. 16, 3 from mesentery, orange color, immature.

## NEMATODES.

4. *Immature nematodes* (*Ascaris*). [Figs. 26, 26*a*.]

The type is here recorded which is characterized in this paper as having an anterior diverticulum of the intestine and a slender posterior diverticulum of the œsophagus, of frequent occurrence in this and other hosts, usually in the mesentery.

1901.—July 17, few. July 19, rather numerous. July 22, few, some of which proved to be young ascarids. Aug. 1, few. Aug. 8, not numerous. Aug. 13, 1. Aug. 15, few; cysts in this lot, which occurred under the serous coat of the stomach appeared to be due to small nematodes. Aug. 20, 26, and 28, few on each date.

1902.—July 22, numerous. Aug. 16, 19, few.

5. *Immature nematodes.* [Figs. 31–32.]

These belong to the type which is characterized by having an elongated bulbous basal portion of the œsophagus, with no diverticulum of the œsophagus, but with an anterior cœcal prolongation of the intestine. The post-anal region is transversely corrugated.

1901.—Aug. 13, 20, 21, few.

1902.—Aug. 11, 19, few.

6. *Heterakis* sp.

This appears to be identical with "*Ascaris* (?) sp," from *Paralichthys dentatus* (Bulletin of U. S. Fish Commission for 1899, p. 481, pl. VII, figs. 207, 208). See also under *Leiostomus*, *Lophopsetta*, and *Sciænops*, and introduction for remarks on *Heterakis*.

1901.—July 17, 1, female, but not with mature ova; length 3.78 mm., length of œsophagus 0.74 mm. July 19, 1, female, not in good condition, the cuticle for two-thirds the length being digested off; ova not developing; length 6.5 mm., length of œsophagus 0.74 mm. Aug. 16, 1, female; length 5 mm., length of œsophagus 0.7 mm. In this specimen the œsophagus was constricted in the middle, giving to it an hourglass shape. The specimen was first supposed to be a male, there being two post-anal papillæ present. In alcohol it measures 4.3 mm. The reproductive aperture was noted 1.8 mm. from the posterior end.

1902.—July 22, 2, females.

7. *Ichthyonema globiceps* Rudolphi. [Fig. 21.]

1902.—Aug. 14, 1, from lower lip. Color reddish, particularly at the posterior end, and due to the perivisceral fluid. Intestine dark brown. The specimen is a female with an enormous number of young, which could be seen as a continuously wriggling mass through the transparent walls of the body and uterus. Dimensions, life, in millimeters: Length 25; diameter, at anterior end 0.10, at nerve ring 0.21, at anterior end of uterus 0.25; distance from anterior end to nerve ring 0.21; from anterior end to anterior end of uterus 0.3; diameter of œsophagus 0.05; diameter of young 0.01. The young are characterized by having half a dozen or less brown granular masses apparently in the intestine.

## CESTODES.

8. *Scolex polymorphus* Rudolphi. [Fig. 79.]

1901.—July 19, numerous in cystic ducts of both hosts examined on this date. July 22, Aug. 8, 15, numerous in cystic duct on each date.

1902.—July 7, 8, 15, few. July 16, abundant. July 18, few, large and small. Aug. 20, numerous.

9. *Cestode.*

1901.—July 17, a slender flask-shaped larva from surface of viscera. Similar to No. 8 under *Leiostomus.*

1902.—Aug. 18, cyst with larva, probably *Dibothrium;* length 4.5 mm.; breadth 0.7 mm.

Agrees with No. 7 under *Lophopsetta maculata.*

10. *Rhynchobothrium* sp. [Figs. 95, 96.]

These are larval forms from small oval cysts in stomach wall, most of them, if not all, belonging to the type designated in these notes as small with relatively large hooks and relatively long contractile bulbs. The hooks of this species agree closely with those figured in Larval Cestode Parasites of Fishes, pl. LXIII, fig. 7 (Proceedings of the National Museum, vol. XIX).

1901.—July 22, several. Aug. 6, 1. This may be a different species from the foregoing, the edges of the bothria being raised into a prominent border. Dimensions in millimeters: Cyst 2.8 by 1.4; blastocyst 1.4 by 1; length of larva 1.1 [figs. 95, 96]. Aug. 26; same as those found on July 22.

1902.—July 22, few, on viscera.

11. *Otobothrium crenacolle* Linton.

1901.—Aug. 21, very numerous, cysts in stomach wall.

12. *Tetrarhynchus bisulcatus* Linton. [Fig. 115.]

1901.—Aug. 21, cyst containing a mass of hooks only. They doubtless represent the remains of a disintegrated scolex. They agree with this species. There are two bunches of hooks piled together irregularly and inclosed in the same cyst. Dimensions in millimeters: Cyst 0.2 by 0.14; thickness of wall 0.017; length of longest hooks 0.023. Aug. 26, scolex from stomach wall.

1902.—July 15, 2. July 18, 31, Aug. 19, 20, 21, few.

13. *Synbothrium filicolle* Linton.

Usually in elongated blastocysts inclosed in thin cysts on viscera, especially on the liver.

1902.—July 22, 2. Aug. 16, few.

TREMATODES.

14. *Distomum monticellii* Linton.

1902.—July 15, 1, immature, but reproductive organs developed sufficiently to admit of determination. Excretory vessels filled with orange-colored spherical concretions, as in No. 9 under *Centropristes striatus*.

15. *Distomum vitellosum* Linton.

1902.—Aug. 18, 1.

16. *Distomum pudens* Linton.

1902.—July 14, 1; length 1.42 mm.; ova 0.07 by 0.04 mm. Specimen in poor condition.

17. *Distomum* sp.

1902.—Aug. 8, 1; length 1 mm.; ova 0.04 by 0.02 mm., conical.

See No. 10 under *Rachycentron canadus*. [Fig. 171.]

18. *Distomum dentatum* Linton.

1901.—Aug. 3, 1; agrees closely with this species, but oral spines missing. The cirrus was spinose and lay for the most part behind the ventral sucker, and rather to the right instead of the left of that organ. Dimensions in millimeters: Length 2; diameter of oral sucker 0.21, of pharynx 0.15, of ventral sucker 0.23; ova 0.065 and 0.037 in the two principal diameters. Aug. 6, 2, in poor condition; the oral spines were missing; otherwise in agreement with this species. Aug. 13, 1. Aug. 16, 12; 1 specimen without ova resembles the distome from the scup described in Bulletin of the U. S. Fish Commission for 1899, page 296, pl. XXXIX, fig. 72. Aug. 20, numerous, 75 counted. In this lot there was a great variety both of form and size. The larger specimens were yellowish-white, thickish and nearly opaque; the smaller specimens more slender than the larger ones, bluish-white and translucent. These two forms appear, however, to be specifically identical. The oral spines, characteristic of the species, are present in the thick opaque specimens, while they appear to be absent from the translucent worms. The latter, indeed, seem to be in poor condition, fragile and degenerate. Cirrus in both kinds armed with minute spines; seen in dorsal view it passes dorsal to the ventral sucker near the right edge of the latter organ in one of the larger opaque individuals, more nearly median in one of the translucent worms. In another larger specimen the cirrus lay to the right of the ventral sucker, the spinous portion being in front of the sucker.

Forms resembling *Distomum* sp., Bulletin of the U. S. Fish Commission for 1899, page 296, figs. 72–74, occur in this lot. Dimensions of 4 specimens in millimeters:

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Length | 1.28 | 2.31 | 3.01 | 4.20 |
| Diameter of oral sucker | .18 | .19 | .22 | .28 |
| Length of pharynx | .12 | .18 | .16 | .22 |
| Breadth of pharynx | .07 | .14 | .16 | .25 |
| Diameter of ventral sucker | .20 | .28 | .23 | .30 |
| Maximum breadth of body | .56 | .95 | .70 | 1.12 |

Ova about same size in all, viz, 0.07 mm. and 0.04 mm. (maximum) in the two principal diameters.

1901.—Aug. 21, numerous, spined and spineless forms as in foregoing lot. The spines were larger in this lot than in former lots, and were imbricated on the anterior part of the body. There were twenty-four spines in each of the circumoral circles. Length of spines on neck 0.02 mm., of longest oral spines 0.06 mm., of spines on cirrus 0.01 mm. Aug. 26, several.

1902.—Aug. 28, 15. Aug. 30, few. In these lots both spined and spineless forms occurred. There was also great diversity of form, long and short oval, pyriform, flask-shape, etc. July 15, few. July 30, 4. Aug. 11, 12. Aug. 14, 1. Aug. 16, 5. Aug. 19, 6. Aug. 20, 10. Small and mature specimens together; some slender and almost spineless.

19. *Distomum valde-inflatum* Stossich.

1901.—Aug. 21, 1, from cyst. This specimen appears to agree with forms which I have been referring to this species. It agrees so well with *D. dentatum*, however, in the same host that there is some reason to regard it as the immature form of that species. Dimensions, in millimeters, of specimen liberated from its cyst: Length 0.62; diameter 0.5; diameter of oral sucker 0.11, of ventral sucker 0.10; pharynx, length 0.05, breadth 0.06; length of oral spines 0.04.

1902.—July 16, several, encysted on the liver and associated with much pigment; spines on body and around mouth, but still very small, the largest of the latter measuring only 0.014 mm. in length, in two rows and shaped like those of No. 18. Another encysted distome is evidently the same as that which I have been recording under the name *D. valde-inflatum*. Dimensions, life, in millimeters, compressed: Length 1.12; diameter, anterior 0.15, at ventral sucker 0.45, near posterior end, maximum, 0.6; diameter of oral sucker 0.12, of pharynx 0.18, of ventral sucker 0.24; length of oral spines 0.04.

20. *Distomum* sp.

1901.—Aug. 28, 1, a filiform specimen, a fragment. Dimensions in millimeters: Length 4; diameter (compressed) 0.16, uniform throughout; ova 0.024 and 0.017 in the two principal diameters, found throughout the greater part of the length of the fragment.

1902.—Aug. 18, 1, a fragment; anterior end of a single specimen. Distance to posterior edge of ventral sucker 1.5; diameter of oral sucker 0.25, of pharynx 0.16, of ventral sucker 0.36.

21. *Gasterostomum gracilescens* Rudolphi. [Fig. 237.]

1902.—July 22, 2, oval, armed with minute spines. Dimensions, life, in millimeters: Length 1.27; breadth 0.6; diameter of anterior sucker 0.2, of mouth 0.08; ova 0.02 by 0.011.

See under *Menidia*, *Tylosurus marinus*, etc.

### **Lophopsetta maculata**, *Sand-shoal Flounder.*

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| July 22 | 10 | The only food material identified was fish scales. |
| August 8 | 7 | Crabs. |
| 1902. | | |
| July 15 | 2 (small) | Mainly small shrimps. |
| July 23 | 1 | Contents of alimentary canal completely digested. |
| August 1 | 3 | Fish. |
| August 11 | 1 | Shrimp. |
| August 18 | 1 (small) | Do. |
| August 25 | 3 (small) | Do. |

ACANTHOCEPHALA.

1. *Echinorhynchus pristis* Rudolphi.

1902.—July 23, 1, male.

NEMATODES.

2. *Ascaris* sp. Immature.

1901.—July 22, from viscera. These belong to the type with a diverticulum from both œsophagus and intestine. Rudiments of the jaws of an *Ascaris* were made out in a specimen from which the embryonic cuticle was sloughing off. Aug. 8, numerous, from viscera. There were numerous clustered cysts on the mesentery which appear to have been due to nematodes, although no worms were found in them.

1902.—July 15, 1. Aug. 1 and 25, few.

3. *Heterakis* sp.

1902.—Aug. 1, 1, a female, and fragment; length 4.2 mm. This is similar to *Ascaris* (?) sp. (Bulletin U. S. Fish Commission for 1899, page 481, pl. VII, figs. 57–61, and probably *Cucullanus* sp., page 441, pl. XVII, figs. 207, 208.)

See introduction for remarks on *Heterakis*.

### CESTODES.

4. *Scolex polymorphus* Rudolphi.

1901.—July 22, numerous.

1902.—July 15, very small. A few noted in small piece of intestine which was being examined under the compound microscope. Aug. 1, few, good size; some from cystic duct.

5. *Tetrarhynchus bisulcatus* Linton.

1902.—July 15, 23, Aug. 1, 18, 25, from cysts in stomach wall.

6. *Synbothrium filicolle* Linton.

1901.—July 22, from viscera; type with slender spine-like hooks on proboscides; hooks with minute notches on the end.

7. *Cestode larva.*

1902.—Aug. 18, an elongated specimen; probably a *Dibothrium*. Agrees with No. 9 under *Paralichthys albiguttus*.

8. *Cysts.*

1901.—July 22, numerous small cysts were found in the stomach-wall which, however, could not be identified.

### TREMATODES.

9. *Distomum appendiculatum* Linton (?).

1902.—July 15, a small appendiculate distome which was accidentally crushed before the examination was complete. The posterior end was filled with ova which concealed the reproductive organs. Dimensions, in millimeters: Diameter of oral sucker 0.09, of ventral sucker 0.21; ova 0.036 by 0.022, many of the ova considerably smaller at one end than the other.

10. *Distomum dentatum* Linton.

1901.—Aug. 8, 2, small specimens without spines and otherwise in poor condition, but apparently belonging to this species.

1902.—July 23, 1, small oval, no spines around mouth, but in other particulars agreeing with this species; ventral sucker but little larger than oral. Also a few very small distomes, length 0.6 mm., were noted, which made their appearance when a comparatively large cyst was broken, liberating the white granular contents. Aug. 11, several.

11. *Distomum* sp.

Same as form shown in fig. 171.

1902.—Aug. 18, 1.

## Etropus crossotus.

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1902. | | |
| August 25 | 1 (small) | Numerous spines of annelids seen in a small piece of the intestine. |

### CESTODES.

1. *Scolex polymorphus* Rudolphi.

One, small.

## Symphurus plagiusa, *Acedia*, "*Sole*."

| Date. | Number of fish examined. | Food notes. |
|---|---|---|
| 1901. | | |
| August 26 | 1 (small) | Small univalve (*Olivia*), setæ of annelids, fragments of fish scales, diatoms. |
| 1902. | | |
| July 7 | 1 (small) | Food not noted. |
| July 14 | 2 (small) | Minute spines and other fragments of small crustacea; fine, white sand. |
| July 17 | 1 (small) | Setæ of annelids, mud and sand. |
| July 21 | do | Annelids, much sand. |
| July 22 | do | Small crustacea and lamellibranchs, setæ of annelids. |
| July 25 | do | Diatoms. |
| July 29 | do | Spines of annelids, sand, etc. |
| July 31 | 2 (small) | Small lamellibranch shell, minute crustacea. |
| August 4 | 3 (small) | Food completely digested; no entozoa. |
| August 13 | 5 (small) | Small crustacea, gastropod shell. |
| August 18 | 3 (small) | Fish, shrimp. |
| August 19 | 1 (small) | Fragments of vegetable tissue. |

ACANTHOCEPHALA.

1. *Echinorhynchus pristis* Rudolphi.

1902.—Aug. 18, fragment of female.

CESTODES.

2. *Scolex polymorphus* Rudolphi.

1902.—July 7, few. July 14, several, with two costæ. July 21, 1, small. July 25, several, comparatively large, with two costæ and red pigment, like young *Acanthobothrium*, but without hooks. July 31, many. Aug. 18, several, elongated, with two costæ and red pigment spots. Aug. 19, few, small.

A larval cestode found on July 17, and looking like an immature *Rhynchobothrium*, is here recorded.

3. *Tetrarhynchus bisulcatus* Linton.

1901.—Aug. 26; scolices from cysts in stomach wall.

1902.—July 25, few. Aug. 13, 6. Aug. 18, 6.

TREMATODES.

4. *Distomum* sp. [Figs. 161–164, 212. See also fig. 209.]

Here are recorded several finds of small distomes which probably belong to the same species. They agree in having the oral sucker equaling or slightly surpassing the ventral sucker in diameter.

(*a*) 1902.—July 7, 1. Dimensions, in millimeters: Length 0.96; breadth 0.51; oral sucker, length 0.09, breadth 0.10; ventral sucker, length 0.09, breadth 0.10. July 21; 2. Dimensions, in millimeters: Length 0.7; breadth 0.3; oral sucker 0.11, ventral sucker 0.10. Ova present; one of the specimens with conspicuous branching vitellaria laterally placed. Aug. 18; 1. Dimensions, in millimeters: Length 0.62; oral sucker 0.10, pharynx 0.04, ventral sucker 0.08. [Fig. 212.]

(*b*) Larger than (*a*). [Fig. 164.] 1902.—July 17, 1. Dimensions, in millimeters: Length 1.35; breadth, anterior 0.18, at ventral sucker 0.51, maximum, a little way behind ventral sucker, 0.57; diameter of oral sucker 0.16, of ventral sucker 0.15; ova 0.022 by 0.014. July 31; 2. Aug. 19; 1.

(*c*) [Figs. 161–163.] 1902.—July 14, 2. These small distomes were found with the aid of the compound microscope in a small piece of the intestine which was under examination for the character of the food. They were not seen until the morning of the 15th, after they had lain overnight in sea water, to which a few drops of formalin had been added. Each was peculiar in being somewhat diagonally truncate at the posterior end. This truncated condition caused such an unusual appearance that they were first, when but slightly magnified, thought to be parts of the same worm accidentally cut in two. Body covered with minute, flat spines, 0.005 mm. in length arranged in transverse rows. Dimensions, in millimeters, of one specimen: Length 0.79; maximum breadth near posterior end 0.35; diameter of oral sucker 0.14, of ventral sucker 0.11; pharynx, length 0.06, breadth 0.045. Corresponding dimensions of the other: Length 0.78; maximum breadth 0.53; diameter of oral sucker 0.15, of ventral sucker 0.12; pharynx, length 0.07, breadth 0.045; ova 0.022 by 0.015.

The stained and mounted specimens show some details of structure which were not evident in the living worms. The testes are two, lateral and posterior; ovary between the right testis and ventral sucker; vitellaria lateral, as far forward as the posterior edge of the ventral sucker in one, nearly to the middle of the ventral sucker in the other. The cirrus appears to pass to the right side of the ventral sucker to the genital aperture in front of that organ. It is relatively large and armed with spines.

No. 8 under *Hexanematichthys* may be an immature example of this distome. [Fig. 209.]

# INDEX.

[Most of the references to the names of parasites which are given in this index are to the list of entozoa with citations to literature (pp. 328–329), and to the lists of parasites and their hosts (pp. 330–336), where detailed references will be found.]

Page
Abudefduf saxatilis, 400
Acanthobothrium paulum, 328, 331
Acedia, 415
Alutera schœpfii, 401
Amber Jack, 363
Anchorella sp, 336
Anguilla chrysypa, 351
Anthobothrium laciniatum, 328, 331
Anthobothrium pulvinatum, 328, 331
Anthocephalum gracile, 328, 331
Archosargus probatocephalus, 382
Argulus sp, 336
Ascaris brevicapitata, 328, 330
  habena, 328, 330
  increscens, 328, 330
  incurva, 328, 330
  inquies, 328, 330
  neglecta, 328, 330
Ascaris sp, 330
Aspidogaster ringens, 327, 333
Bairdiella chrysura, 387
Barndoor skate, 346
Barracuda, 361
Big-eyed herring, 352
Black sea bass, 375
Blenny, 410
Blue-fish, 368
Blue shark, 341
Bonnet-head shark, 344
Bomolochus sp, 336
Brachiella sp, 336
Brevoortia tyrannus, 352
Bucephalus, 327
Butterfly ray, 348
Cabio, 370
Calidris arenaria, 409
Calliobothrium sp, 342
Caligus sp, 336
Caranx hippos, 365
Carcharhinus milberti, 341
  obscurus, 339
Centropristes striatus, 375
Cercariæ, 401
Cero, 362
Cestode larvæ, 331, 375, 378, 395
Chætodipterus faber, 400
Chilomycterus schœpfi, 403
Chondracanthus sp, 336
Chub, 383
Cobia, 370
Conger eel, 351
Copepod parasites, 336
Coryphæna equisetis, 373
  hippurus, 372
Cow-pilot, 400
Crevallé, 365
Croaker, 394
Crossobothrium angustum, 328, 331
Cucullanus (*see* Heterakis).

Page
Cynoscion nebulosus, 385
  regalis, 384
Cysts, 341, 344, 348, 350, 401, 415
Dactylocotyle sp, 333
Dasyatis say, 346
Dibothrium, fragment, 354
  larvæ, 331
  tortum, 325, 331
Diclidophora sp, 333
Diplodus holbrookii, 383
Distomum aduncum, 327, 333
  appendiculatum, 328, 333
  areolatum, 328, 334
  bothryophoron, 328, 334
  corpulentum, 327, 334
  dentatum, 328, 334
  globiporum, 328, 334
  grandiporum, 328, 334
  hispidum, 328, 334
  imparispine, 327, 334
  inconstans, 327, 334
  monticellii, 327, 328, 334
  nigroflavum, 328, 334
  pectinatum, 327, 334
  polyorchis, 328, 334
  pudens, 328, 334
  pyriforme, 328, 334
  simplex, 328, 334
  tenue, 328, 334
  tornatum, 328, 334
  valde-inflatum, 329, 334
  vibex, 329, 334
  vitellosum, 329, 335
Distomum sp, 335
Dolphin, common, 372
  small, 373
Dusky shark, 339
Echeneibothrium sp, 331
Echinorhynchus pristis, 325, 329, 330
  proteus, 329, 330
  sagittifer, 325, 329, 330
Echinorhynchus sp, 330
Eel, 351
Elops saurus, 352
Ergasilus, 336
Etropus crossotus, 415
Eucinostomus gula, 383
Fat-back, 352
Filaria galeata, 329, 330
File-fish (Monacanthus), 401
  (Alutera), 401
Flounder, 410, 411
Fundulus heteroclitus, 356
  majalis, 355
Galeichthys milberti, 349
Gar, 356, 357, 358
Gasterostomum arcuatum, 329, 335
  baculum, 327, 329, 335
  gorgon, 327, 335
  gracilescens, 327, 335

Page.
Gasterostomum sp 335
Goat-fish 361
Gregarines 359
Gulf flounder 411
Halfbeak 358
Heterakis foveolata 329, 330
Heterakis sp 329, 330
Hog-fish 376
Hyporhamphus roberti 358
Hypsoblennius hentz 410
Ichthyonema globiceps 329, 330
Ichthyonema sp 330
Immature nematodes (Ascaris) 330, 331
Killi-fish 355, 356
Kyphosus sectatrix 383
Lagodon rhomboides 380
Lecanicephalum peltatum 329, 331
Lecanocephalus annulatus 329, 331
Leiostomus xanthurus 391
Leptocephalus conger 351
Lernæonema 336
Lernanthropus 336
Lizard-fish 353
Lophopsetta maculata 414
Menhaden 352
Menidia menidia 360
Menticirrhus americanus 398
Micropogon undulatus 391
Microcotyle sp 335, 370, 384
Monacanthus hispidus 401
Monostomum vinal-edwardsii 329, 335
Monostomum sp 335
Moon-fish 365
Mugil braziliensis 360
    cephalus 361
Mullet 361
Myxobolus sp 335
Needle-fish 357
Nematodes, immature 330, 331
    minute 331
Onchobothrium uncinatum 329, 331
Opsanus tau 406
Orthopristis chrysopterus 376
Otobothrium crenacolle 326, 329, 331
    dipsacum 329, 331
    insigne 329, 331
Otobothrium sp 331
Oyster, parasite of 327
Pandarus sp 336
Paralichthys albiguttus 411
    dentatus 410
Paratænia medusia 329, 331
Phoreiobothrium lasium 329, 331
    triloculatum 329, 331
Phyllobothrium foliatum 329, 331
Pin-fish, common 380
    spotted 383
Pipe-fish 359
Pomatomus saltatrix 368
Pompano 366
Porgee 400
Prionotus scitulus 404
    tribulus 404
Pteroplatea maclura 348
Puffer 402
Rabbit-fish 403
Rachycentron canadus 370
Raja lævis 346

Page
Red drum 390
Red goat-fish 361
Rhinebothrium flexile 325, 332
Rhinebothrium sp 325, 332
Rhynchobothrium bulbifer 329
    hispidum 329, 332
    plicatum 325, 332
    speciosum 325, 329, 332
    tenuispine 329, 332
    tumidulum 329, 332
Rhynchobothrium sp 332
Rock-fish 355
Rudder-fish 383
Sanderling 409
Sand pike 353
Sciænops ocellatus 390
Scolex polymorphus 326, 329, 332, 333
Scoliodon terræ novæ 342
Scomberomorus maculatus 362
    regalis 362
Sea cat-fish 349
Sea mullet 398
Sea robin 404
Selene vomer 365
Seriola lalandi 363
Sharp nosed shark 342
Sheepshead 382
Silver jenny 383
Silver perch 387
Silverside 360
Siphostoma fuscum 359
Small dolphin 373
Sole 415
Spanish mackerel 362
Spheroides maculatus 402
Sphyræna borealis 361
Sphyrna tiburo 344
Spongiobothrium variabile 329, 333
Sporozoa 335
Spot 391
Spotted pin-fish 383
Spotted weak-fish 385
Squeteague 384
Sting ray 346
Stolephorus brownii 353
Striped anchovy 353
Summer flounder 410
Symphurus plagiusa 415
Synbothrium filicolle 326, 329, 333
Synbothrium sp 326, 333
Synodus fœtens 353
Tænia sp 333
Tetrarhynchus bicolor 329, 333
    bisulcatus 329, 333
    robustus 329, 333
Toad-fish 406
Trachinotus carolinus 366
Trout, gray 384
    spotted 385
Tylosurus caribbæus 358
    marinus 356
    raphidoma 357
Upeneus maculatus 361
Weak-fish 384
Whiting 398
Window-pane 414
Yellow-tail 387

## EXPLANATION OF PLATES.

### PLATE I.

*Echinorhynchus sagittifer* Linton. Adult. From cobia (*Rachycentron canadus*).

FIGS. 1–4.—Male, mounted in balsam. Actual length 34 mm.; *s h*, proboscis sheath; *c g*, cement glands; *e d*, ejaculatory duct; *b*, bursa.

FIG. 5.—Portion of one of the transverse groups of spines with which the anterior part of the body is armed; × 210.

### PLATE II.

*Echinorhynchus sagittifer* Linton. Adult. From cobia (*Rachycentron canadus*).

FIG. 6.—Anterior end of female with proboscis, neck, and anterior end of body everted. Sketched from life; × 20.

FIG. 7.—Proboscis of same. × 80.

*Echinorhynchus pristis* Rudolphi. From spot (*Leiostomus xanthurus*).

FIG. 8.—Anterior end of male. Sketched from life; × 50. Letters same as in Figs. 1 to 4.

FIG. 9.—Posterior end of same. Life; × 50. Letters as before.

FIG. 10.—View of proboscis at about middle of its length. × 315.

FIG. 11.—Hooks from circle near base of proboscis. × 315.

### PLATE III.

*Echinorhynchus pristis* Rudolphi. From spot (*Leiostomus xanthurus*).

FIG. 12.—Hooks near base of proboscis. × 315.

FIG. 13.—Spines from anterior end of body, a little posterior to those figured next. × 315.

FIG. 14.—Spines from anterior end of body just back of neck. × 315.

*Echinorhynchus* sp. From gray trout (*Cynoscion regalis*).

FIG. 15.—Fragment of female, posterior end, lateral view. Life; × 50.

FIG. 16.—Dorsal view of same. Life; × 50.

*Filaria galeata*, sp. nov. From bonnet-head shark (*Sphyrna tiburo*).

FIG. 17.—Posterior end of male, lateral view; *s p*, spicule. Life; × 315.

### PLATE IV.

*Filaria galeata*, sp. nov. From bonnet-head shark (*Sphyrna tiburo*).

FIG. 18.—Anterior end; *n r*, nerve ring. × 315.

FIG. 19.—Same, opposite side. × 315.

FIG. 20.—Posterior end of male from stomach of small dolphin (*Coryphæna equisctis*), evidently introduced with food. × 170.

*Ichthyonema globiceps* Rudolphi. From lip of flounder (*Paralichthys albiguttus*).

FIG. 21.—Anterior end. Actual diameter of head, 0.1 mm. *u*, Uterus with young.

*Ascaris brevicapitata* Linton, immature. From stomach of dusky shark (*Carcharhinus obscurus*).

FIG. 22.—Anterior end. Actual diameter of jaws, 0.15 mm.

FIG. 23.—Posterior end of same. Actual distance from anal aperture to tip, 0.37 mm.

*Heterakis* sp. From drum (*Sciænops ocellatus*).

FIG. 24.—Posterior end, ventral view. Life; × 210.

## PLATE V.

*Heterakis* sp. From drum (*Sciænops ocellatus*).

FIG. 25. Anterior end. Life; × 315.

Immature nematodes (*Ascaris*).

FIG. 26.—Anterior end of specimen from flounder (*Paralichthys albiguttus*), showing junction of œsophagus and intestine. Life; × 540.

FIG. 26a.—Posterior end of same, lateral view. Life; × 315.

FIG. 27.—Specimen from toad-fish (*Opsanus tau*). Life; × 315.

FIG. 28.—Another specimen from same host. Actual diameter at base of œsophagus, 0.4 mm. Probably the young of *Ascaris habena*.

FIG. 29.—Anterior end of specimen from gar (*Tylosurus raphidoma*). Life; × 50. Same type as that shown in Figs. 27 and 28.

FIG. 30.—Posterior end of same. Life; × 210.

## PLATE VI.

Immature nematodes (*Ascaris*).

FIG. 31.—Specimen from flounder (*Paralichthys albiguttus*). In this type the bulbous base of the œsophagus is elongated and without diverticulum.

FIG. 32.—Posterior end of another specimen of same type. Life; × 315.

FIG. 33.—Two specimens and three calcareous bodies in cyst from black sea bass (*Centropristis striatus*). Life; × 50.

FIG. 34.—Cyst containing young nematodes from body cavity of blue-fish (*Pomatomus saltatrix*). Actual length of cyst, 1.44 mm.

FIG. 35.—Small nematode from spot (*Leiostomus xanthurus*); posterior end of male. × 525.

## PLATE VII.

Minute nematodes from spot (*Leistomus xanthurus*).

FIG. 36.—Female, collected August 18, 1902. Actual length, 1 mm.

FIG. 37.—Enlarged view of head of same.

FIG. 38.—Male from same lot. Actual length, 1 mm.

FIG. 39.—Enlarged view of same.

FIG. 40.—Female, same host, collected July 8, 1902. Actual length, 1.2 mm.

FIG. 41.—Anterior end of same, lateral view. × 525.

FIG. 42.—Posterior end of male. × 300.

FIG. 43.—Male, different species from foregoing, lateral view of head. Actual length of specimen, about 3 mm.

FIG. 44.—Copulatory spines of same. × 170. (See Fig. 51.)

FIG. 45.—Another species from same host, collected July 25, 1902; female. Actual length, 2 mm.

## PLATE VIII.

Minute nematodes.

FIG. 46.—Female, enlarged view of head of specimen from *Leiostomus xanthurus* sketched in Fig. 45. Actual diameter behind spines, 0.03 mm.

FIG. 47.—Outline of posterior end, lateral view of same. Diameter at anal aperture, 0.04 mm.

FIG. 48.—Outline of posterior end of male from *Leiostomus xanthurus*. The head of this specimen was like that sketched in Fig. 46; from lot collected July 29, 1902. × 300.

FIG. 49.—Small nematode agreeing with specimen from spot, Fig. 46, but from silver jenny (*Eucinostomus gula*). Diameter at *x*, 0.1 mm.

FIG. 50.—Lateral view of posterior end of male from same lot. Diameter at anal aperture, 0.76 mm.

FIG. 51.—Outline of specimen from *Leiostomus xanthurus* shown in Figs. 43 and 44. × 46.

FIG. 52.—Copulatory spines from male from *Leiostomus xanthurus* collected August 4, 1902. Actual length of spicules, chord of arc, 0.12 mm. In this lot were specimens with same type of head shown in Figs. 40 and 41. The worm from which this sketch was made was larger than the others, and the tail was elongated as in Fig. 47.

FIG. 53.—Anterior end of male from *Leiostomus xanthurus* collected July 17, 1902. Actual length of worm about 3 mm. Optical section, × 300.

FIG. 54.—Posterior end of same. Optical section, × 300.

Sporozoa.

FIG. 55.—Piece of intestine of pompano (*Trachinotus carolinus*) with cysts containing sporozoa. Life; about natural size.

FIG. 56.—Sporozoa from drum (*Sciænops ocellatus*). Actual breadth, 0.01 mm. Life.

Parasitic copepod.

FIG. 57.—Specimen from gills of mullet (*Mugil cephalus*), lateral view. Life; actual length, 6 mm. *c l*, Modified appendages which form a clasping organ to slip over a gill filament of the host.

FIG. 58.—Sketch of specimen which had lain in water a few days.

## PLATE IX.

*Rhinebothrium* sp., from toad-fish (*Opsanus tau*).

FIG. 59.—Cluster of cysts from surface of liver. Life; enlarged about 2 diameters.

FIG. 60.—Small cluster detached from No. 59 and flattened under cover glass. × 6. *d*, Small cyst containing a distome (*D. valde-inflatum*). The remaining cysts contain blastocysts, which in turn contained larvæ.

FIG. 61.—A single cyst and blastocyst. The latter is seen to be much elongated, with an enlargement at the distal end. Life; × 6.

FIG. 62.—An enormously elongated blastocyst removed from its cyst, flattened, and showing a larva through the transparent wall. Life; × 50.

FIG. 63.—Cyst with contained blastocyst, slightly enlarged.

FIG. 64.—Blastocyst removed from No. 63 and compressed. The posterior ends of two of the bothria of the larva are seen protruding from the anterior end.

FIG. 65.—Larva (scolex) removed from blastocyst.

FIG. 66.—Small dumb-bell-shaped blastocyst in its cyst; optical section of specimen mounted in balsam; × 70.

## PLATE X.

*Rhinebothrium* sp., from *Opsanus tau*.

FIG. 67.—Cyst containing blastocyst. Life; × 20. *b*, Blood vessels distributed over wall of cyst; *ex p*, excretory pore.

FIG. 68.—Front view of head of embryo; partly diagrammatic. Life; × 50.

FIG. 69.—Section, nearly longitudinal through cyst, blastocyst, and larva. × 110.

FIG. 70.—Anterior end of blastocyst, showing orifice and pit into which the scolex is retracted. Sketched from another section of same series from which No. 69 was made. × 110.

FIG. 71.—Diagrammatic sketch, showing plan of arrangement of loculi.

## PLATE XI.

*Rhinebothrium* sp. from *Opsanus tau*.

FIG. 72.—Transverse section of cyst with blastocyst and larva. × 110.

FIG. 73.—Portion of walls of cyst and blastocyst. × 525.

FIG. 74.—Transverse section of wall of blastocyst. × 525.

FIG. 75.—Part of viscera of pipe-fish (*Siphostoma fuscum*) with cysts containing larvæ of *Rhinebothrium* sp., same species as the one found in the toad-fish. Life; × 3. *g b*, gall-bladder; *i*, intestine; *l*, liver; *s*, stomach.

### *Scolex polymorphus* Rudolphi.

Fig. 76.—From alimentary canal of toad-fish (*Opsanus tau*). Life; × 80. This suggests the genus *Calliobothrium*.

Fig. 77.—Same, more highly magnified. × 315.

Fig. 78.—Specimen showing different states of contraction. *a*, View of entire specimen; *b* and *c*, posterior end of same. The numerals 1, 2, and 3 refer to identical parts in the several sketches. Actual length of *a* about 0.38 mm.

Fig. 79.—One larger, many small specimens from flounder (*Paralichthys albiguttus*) in place on intestine. Life; × 72.

## PLATE XII.

Fig. 80.—*Calliobothrium* (?) sp. from the sharp-nosed shark (*Scoliodon terræ-novæ*). Young scolex with rudiments of hooks. Life; × 135.

Fig. 81.—Blastocyst from body cavity of blue-fish (*Pomatomus saltatrix*). Anterior end, life. The length of the entire specimen was 12 mm and its breadth 2 mm. 1. Anterior end, tip everted. 2. Same, retracted. 3. Anterior tip showing characteristic knobbed bristles.

### Larval cestodes.

Fig. 82. *Echeneibothrium* sp. Immature scolex from sting ray (*Dasyatis say*). Life; actual length of head about 0.5 mm; length of specimen 5 mm.

Fig. 83.—Specimen from croaker (*Micropogon undulatus*). Life; actual length 5 mm.

Fig. 83a.—Another from same host, different date. Length 7 mm.

Fig. 84.—Cyst with blastocyst from body cavity of toad-fish (*Opsanus tau*). Actual length of cyst 1.35 mm.

### *Tænia* sp. from body cavity of rock-fish (*Fundulus majalis*).

Fig. 85.—Scolex with rostellum retracted. Life; actual diameter through suckers 0.9 mm.

Fig. 86.—Hook of same. Actual length 0.22 mm.

### *Rhynchobothrium* sp. encysted.

Fig. 87.—Cyst with blastocyst and larva from mesentery of croaker (*Micropogon undulatus*). Life; × 50.

Fig. 88.—Same, larva everted, but still attached to the blastocyst. × 50.

## PLATE XIII.

### *Rhynchobothrium* sp.

Fig. 89.—Same as No. 88, larva compressed and proboscides everted. × 80. This type was found many times during the season and in several species of fish.

Fig. 90.—Portion of proboscis of same. × 315.

Fig. 91.—Portion of proboscis near apex. Specimen collected from same host (*Micropogon undulatus*), but on different date. × 315.

Fig. 92.—Proboscis of same as No. 91 toward base. × 315.

Fig. 93.—Cyst of probably same species from silver perch (*Bairdiella chrysura*), compressed and showing blastocyst and contained larva. × 20.

Fig. 94.—Portion of proboscis of specimen from black sea bass (*Centropristes striatus*). × 540.

Fig. 95.—Cyst with blastocyst and larva from stomach wall of flounder (*Paralichthys albiguttus*). Actual length, 2.48 mm.

Fig. 96.—Larva removed from cyst, Fig. 95. Actual length, 1.1 mm.

Fig. 97.—Cyst with blastocyst and larva from silver perch (*Bairdiella chrysura*). × 20. Type with neck and proboscides rather long and hooks short and close together.

Fig. 98.—Proboscides of specimen of *Rhynchobothrium*, probably same species as Fig. 97, from mesentery of hog-fish (*Orthopristis chrysopterus*). × 540.

Fig. 99.—Cyst with blastocyst and larva from big-eyed herring (*Elops saurus*). Actual length of cyst, 5 mm.

Fig. 100.—Portion of proboscis of same. × 540.

## PLATE XIV.

FIG. 101.—*Rhynchobothrium tenuispine* Linton, from cyst on viscera of croaker (*Micropogon undulatus*). Sketch from life; × 80.

*Otobothrium* sp. from muscles of gar (*Tylosurus raphidoma*).

FIG. 102.—Cyst containing blastocyst. Life; actual length, 8 mm.
FIG. 103.—Blastocyst removed from cyst
FIGS. 104–107.—Larvæ removed from blastocysts. Actual length at rest, 4 to 5 mm. The true relation of the bothria to the notch at the base of the neck is shown in Fig. 107.
FIG. 108.—Posterior end of bothrium showing the two auxiliary acetabula.
FIG. 109.—One of the auxiliary acetabula greatly enlarged.

*Otobothrium crenacolle* Linton.

FIG. 110.—Cyst with two blastocysts. From hog-fish (*Orthopristis chrysopterus*). Actual diameter of cyst, 2 mm.
FIG. 111.—Cyst from stomach wall of cero (*Scomberomorus regalis*). Actual length of blastocyst, 1 mm. Thick-walled, amber-colored cyst containing blastocyst with larva.

## PLATE XV.

*Otobothrium crenacolle* Linton.

FIG. 112.—Cyst with blastocyst from submucous coat of stomach of gray trout (*Cynoscion nebulosus*). Life; actual length 1.2 mm.
FIG. 113.—Larva from same. Life; × 135.
FIG. 114.—Portion of proboscis of same. Life; × 540.
FIG. 115.—Cyst formed around two masses of hooks, which are probably those of *Tetrarhynchus bisulcatus* Linton, from flounder (*Paralichthys albiguttus*). Actual length of cyst 0.2 mm.

*Synbothrium* sp., from surface of viscera of gray trout (*Cynoscion regalis*).

FIG. 116.—Proboscis, near base. × 315.
FIG. 117.—Same, near middle. × 315.
FIG. 118.—Same, near apex. × 315.

## PLATE XVI.

*Dibothrium tortum*, sp. nov., from sand pike (*Synodus fœtens*).

FIG. 119.—Sketch from life enlarged. Most specimens are relatively more slender than the one represented in the sketch. Anterior egg clusters nearly transverse, succeeding ones becoming diagonal.
FIG. 120.—Fragment from posterior end with egg clusters but little inclined to the axes of the body.
FIG. 121.—Anterior end of living specimen. Actual diameter at $x$, 0.45 mm.
FIG. 122.—Anterior end of alcoholic specimen. Actual diameter at anterior end 0.36 mm.
FIG. 123.—Sketch of body with three sets of genitalia. Specimen mounted in balsam. Actual breadth 1.7 mm.
FIG. 124.—Sketch of two sets of genitalia. Life, with a few details added from stained specimens. × 300.

## PLATE XVII.

FIG. 125.—Three views of head of *Anthobothrium pulvinatum* Linton, from the sting ray (*Dasyatis say*). Sketched from living specimen showing some of the characteristic contraction stages; × 4.
FIG. 126.—Free segment of *Anthobothrium laciniatum* Linton, from the sharp-nosed shark (*Scoliodon terræ-novæ*). × 50. *s g*, Shell gland.
FIG. 127.—*Onchobothrium uncinatum* Diesing, from the sting ray (*Dasyatis say*). Sketch from life. Actual length 48 mm.
FIG. 128.—*Acanthobothrium paulum* Linton, from the butter-fly ray (*Pteroplatea maclura*). Free-hand sketch of single bothrium. Life.

Fig. 129.—*Rhynchobothrium* sp., from sharp-nosed shark (*Scoliodon terræ-novæ*). Lateral view of head. Life.

Fig. 129a.—Front view of same. Life.

Fig. 130.—Same species, head and neck, alcoholic specimen. Actual diameter of bothrium 1.12 mm.

Figs. 130a and 130c.—Different views of proboscis; larger hooks on medial side. Actual diameter of proboscis, excluding hooks, 0.15 mm.

## PLATE XVIII.

Fig. 131.—*Rhynchobothrium* sp., from sting ray (*Dasyatis say*). One view of proboscis, sketched from specimen in balsam. Actual diamter, excluding hooks, about 0.09 mm.

*Rhynchobothrium plicatum*, sp. nov., from bonnet-head shark (*Sphyrna tiburo*).

Fig. 132.—Head, neck, and anterior segments. Life; × 50.

Fig. 133.—Outline of median and post-median segments. × 50.

Fig. 134.—Median segment. Life; × 80.

Fig. 135.—Segment toward posterior end. Life; × 50. This specimen was stained and mounted in glycerin when a conspicuous rudiment of the uterus became visible along the median line which was not seen in the living specimen and is not included in the sketch.

Fig. 136.—Posterior segment. Life. Actual length about 3 mm.

Fig. 137.—Ova. × 210. No bristles were seen on these ova, although in another segment of the same worm ova were seen with bristles as shown in the next figure.

Fig. 138.—Ovum armed with bristles. × 540.

## PLATE XIX.

*Rhynchobothrium plicatum*, sp. nov., from bonnet-head shark (*Sphyrna tiburo*).

Fig. 139.—Immature specimen. Life; actual length 4.8 mm. *r*, Patch of red pigment.

Fig. 140.—Another with scolex partly retracted. Life; actual length 4.5 mm.

*Otobothrium insigne*, sp. nov., from dusky shark (*Carcharhinus obscurus*).

Fig. 141.—Sketch of specimen mounted in balsam. Actual diameter of head 1.2 mm. *b*, Contractile bulbs; *s*, proboscis sheath.

Fig. 142.—Same, more enlarged.

Fig. 143.—View of another specimen, also in balsam. Actual diameter of head 1.35 mm.

Figs. 144 and 145.—Views of opposite sides of the same proboscis at about the same level. Actual diameter, excluding hooks, 0.06 mm.

*Rhynchobothrium hispidum* Linton, from the sting ray (*Dasyatis say*).

Fig. 146.—Strobile. Life; × 50. *r*, Red pigment.

## PLATE XX.

*Microcotyle* sp., from gill of blue-fish (*Pomatomus saltatrix*).

Fig. 147.—Sketch of damaged specimen. Life; actual length 1.85 mm.

Fig. 148.—Cirrus of same, diagrammatic. × 525.

Fig. 149.—One of the small suckers from posterior end of another specimen. Actual length 0.042 mm. There were about 50 pairs of these suckers.

Fig. 150.—Hooks from cirrus; actual length about 0.015 mm.

*Dactylocotyle* sp., from menhaden (*Brevoortia tyrannus*).

Fig. 151.—Sketch of damaged specimen. × 66. *a*, Posterior lobe with hook, more highly magnified.

*Distomum appendiculatum* Rudolphi.

Fig. 152.—Dorsal view. From hog-fish (*Orthopristis chrysopterus*). Life; actual length 1.26 mm.

Fig. 153.—Same from sea robin (*Prionotus tribulus*); ventral view. Actual length 1.12 mm.

## PLATE XXI.

*Distomum monticellii* Linton.

FIG. 154.—Specimen from cobia (*Rachycentron canadus*). Actual length 5 mm. Sketched from life, but some details added from stained and mounted specimens.

FIG. 155.—Ovary and vitellaria of distome identified as this species, from the sand pike (*Synodus fœtens*). Actual length of distome 4.2 mm.

*Distomum tornatum* Rudolphi. From the whiting (*Menticirrhus americanus*).

FIG. 156.—Sketch made from specimen in glycerin. Actual length 10 mm.

FIG. 157.—Ova of distome from sea robin (*Prionotus scitulus*). Actual length 0.03 mm.

## PLATE XXII.

FIG. 158.—*Distomum monticellii* Linton. Immature specimen from black sea bass (*Centropristes striatus*). Actual length 1.17 mm.

FIG. 159.—*Distomum globiporum* Rudolphi (?), from rock-fish (*Fundulus majalis*). Actual length 2.25 mm.

FIG. 160.—*Distomum appendiculatum* Rudolphi, from menhaden (*Brevoortia tyrannus*). Specimen in poor condition when found. Actual length 0.63 mm.

FIGS. 161 and 162.—Distomes from sole (*Symphurus plagiusa*). These specimens were obliquely and conspicuously truncate when first seen, becoming somewhat less so under pressure. Actual length 0.78 and 0.79 mm., respectively; specimens in weak formalin when sketched.

FIG. 163.—Spines from anterior regions of same. Actual length of spine 0.005 mm.

FIG. 164.—Probably same species, from same host, but collected on different date. Sketch made from stained specimen mounted in balsam; actual length 1.05 mm.

FIG. 165.—*Distomum* sp., from puffer (*Spheroides maculatus*). Actual length 1.27 mm.

FIG. 166.—Immature distome in intestine of anchovy (*Stolephorus brownii*). Actual length 0.25 mm.

FIG. 167.—*Distomum* sp., from toad-fish (*Opsanus tau*). Actual length 0.65 mm.; life. Like many finds of distomes, in poor condition when seen; from same lot as figure 205. Dorsal view. Ova in this species distinctly fusiform.

## PLATE XXIII.

Distomes from silver perch (*Bairdiella chrysura*).

FIG. 168.—Ventral view. Life; actual length 0.8 mm.

FIG. 169.—Another specimen from same lot. Life; × 135.

FIG. 170.—Another specimen from same lot. Life; × 80.

Figures 168, 169, and 170 were sketched from living specimens collected on the same day. See text for notes. Incidentally these figures show some of the difficulties which are encountered in identifying distomes.

*Distomum* sp., from cobia (*Rachycentron canadus*).

FIG. 171.—Lateral view. Life; actual length 1 mm.

FIG. 172.—Ova of same. Actual length 0.04 mm.

*Distomum globiporum* Rudolphi. From spot (*Leiostomus xanthurus*).

FIG. 173.—Immature specimen, dorsal view. Actual length 0.9 mm. (See Figs. 198, 199.)

*Distomum bothryophoron* Olsson. From hog-fish (*Orthopristis chrysopterus*).

FIG. 174.—Ventral view. Life; actual length 1 mm.

FIG. 175.—Dorsal view of same. Life.

## PLATE XXIV.

*Distomum vitellosum* Linton.

Fig. 176.—From the drum (*Sciænops ocellatus*). Ventral view. × 80.

Fig. 177.—Lateral view of specimen from same host but collected on different date. Life. When subjected to pressure, the specimen assumed proportions like those in the following figure.

Fig. 178.—From silver perch (*Bairdiella chrysura*). Life; × 50. The characteristic lobes around the ventral sucker are shown in Figs. 177 and 178.

*Distomum* sp., from pin-fish (*Lagodon rhomboides*).

Fig. 179.—Ventral view. Life; actual length 2 mm.

## PLATE XXV.

*Distomum corpulentum*, sp. nov., from pin-fish (*Lagodon rhomboides*).

Fig. 180.—Ventral view. Life; × 50.

Fig. 181.—Ventral view of specimen compressed. Life; × 50. In this specimen the ova were escaping from the posterior edge, which appeared to be somewhat macerated.

Fig. 182.—Dorsal view of a larger specimen. Life; × 50. *i d*, Diverticula of intestine.

## PLATE XXVI.

*Distomum inconstans*, sp. nov., from porgee (*Chætodipterus faber*).

Fig. 183.—Four individuals showing some shapes assumed. Life; actual length 1 to 2 mm.

Fig. 184.—Another specimen from same lot, compressed, ventral view. × 50.

Fig. 185.—Dorsal view of another specimen, same lot. Life; × 80.

Fig. 186.—Ventral view of another specimen. Life; × 80.

Fig. 187.—Spines from under side of neck. × 540.

## PLATE XXVII.

*Distomum vibex* Linton. From puffer (*Spheroides maculatus*).

Fig. 188.—Ventral view. Life; actual length 6 mm. *i d*, Diverticula of intestine.

*Distomum imparispine*, sp. nov., from cobia (*Rachycentron canadus*).

Fig. 189.—Ventral view. Life; actual length 9 mm.

Fig. 190.—Ventral view of head. × 108.

Fig. 191.—Dorsal view of same. × 108.

Fig. 192.—Sagittate spines from under side of neck. × 315.

Fig. 193.—Spines on margin of neck. × 315.

Fig. 194.—Spines on body just back of ventral sucker. × 315.

*Distomum aduncum*, sp. nov., from toad-fish (*Opsanus tau*).

Fig. 195.—Sketch of specimen lying in formalin. × 80.

Fig. 196.—Ventral view. Sketch from life, but a few details added from specimen stained and mounted in balsam. Actual length 0.87 mm. *a c*, Ventral sucker; *g a*, genital acetabulum.

Fig. 197.—Cirrus, cirrus-pouch, etc. Sketched from living specimen. × 315. *h*, Hooks, three in number, on cirrus; *v s*, ventral sucker.

## PLATE XXVIII.

*Distomum globiporum* Rudolphi. From spot (*Leiostomus xanthurus*).

Fig. 198.—Ventral view. Actual length 2.3 mm.

Fig. 199.—Spines from neck. × 540. (See Fig. 173.)

*Distomum pectinatum*, sp. nov., from silver perch (*Bairdiella chrysura*).

Fig. 200.—Dorsal view. Life; × 80.

Fig. 201.—Ventral view of another specimen. Life; × 80.

## PLATE XXIX.

### *Distomum pectinatum.* From silver perch (*Bairdiella chrysura*).

FIG. 202.—Dorsal view of head. Life; × 315.
FIG. 203.—Ventral view of head and part of neck. Life; × 315.

### *Distomum* sp., from the pompano (*Trachinotus carolinus*).

FIG. 204.—Longitudinal section. Actual length 5.5 mm.

### *Distomum* sp.

FIG. 205.—From the toad-fish (*Opsanus tau*), same lot as 167 Ventral view. Ova peculiar in being distinctly fusiform.
FIG. 206.—Imperfect specimen from amber jack (*Seriola lalandi*). The specimen simulates a segmented worm. Actual length 5 mm.
FIG. 207.—Longitudinal and nearly horizontal section of same.
FIG. 208.—Immature specimen from rabbit-fish (*Chilomycterus schoepfi*). Actual length 1.06 mm.
FIG. 209.—Immature specimen from sea cat-fish (*Galeichthys milberti*). Actual length 1.8 mm.

## PLATE XXX.

### *Distomum* sp.

FIG. 210.—From butter-fly ray (*Pteroplatea maclura*). Specimen removed from capsule. Actual length 1.35 mm.
FIG. 211.—Immature specimen from barracuda (*Sphyræna borealis*). Actual length 0.24 mm.
FIG. 212.—Immature specimen from sole (*Symphurus plagiusa*). Actual length 0.62 mm.
FIG. 213.—Immature specimen from intestine of common dolphin (*Coryphæna hippurus*). Ventral view. Actual length 2.5 mm.
FIG. 214.—Immature specimen, apparently same species as shown in figure 213. Actual length 2.4 mm.
FIG. 215.—Distomum (?) sp., from toad-fish (*Opsanus tau*). Lateral view. Actual length 2.8 mm. *ex c*, Material extruded from excretory vessel.

### *Monostomum* sp., from hog-fish (*Orthopristis chrysopterus*).

FIG. 216.—Sketch of specimen not in good condition; peculiar in that the species bears a superficial resemblance to *Gasterostomum arcuatum*. Actual length 2.25 mm.

## PLATE XXXI.

### *Monostomum* sp.

FIG. 217.—From rock-fish (*Fundulus majalis*). Actual length 1.12 mm., life.
FIG. 218.—From hog-fish (*Orthopristis chrysopterus*). Actual length 1.4 mm. (See Fig. 216.)
FIG. 219.—Ova and yellow bodies from uterus of same. Actual length of ovum 0.025 mm.
FIG. 220.—*Monostomum vinal-edwardsii* Linton, immature, from toad-fish (*Opsanus tau*). Life; actual length 1 mm. *ex p*, Excretory pore.
FIG. 221.—Excretory pore of same. Life; × 525.
FIG. 222.—Monostomum sp., from hog-fish (*Orthopristis chrysopterus*). Life; actual length 0.86 mm.
FIG. 223.—From same host. Ventral view, life. Actual length 0.9 mm.
FIG. 224.—Cirrus, genital acetabulum, etc., dorsal view. Life; × 315.
FIG. 225.—Ova. × 540.
FIG. 226.—From pompano (*Trachinotus carolinus*). Actual length 0.87 mm.

## PLATE XXXII.

### *Monostomum.*, from pompano (*Trachinotus carolinus*).

FIGS. 227 and 228.—Two specimens from same lot as 226. Life; actual length of larger 1.5 mm.
FIG. 229.—Ova. Actual breadth 0.017 mm.

*Gasterostomum gracilescens* Rudolphi, from crevalle (*Caranx hippos*). (See Figs. 236–239.)

Fig. 230.—Ventral view, life; actual length 1.17 mm.
Fig. 231.—Spines from body. × 540.
Fig. 232.—Pharynx, etc. × 315.

*Gasterostomum baculum*, sp. nov., from Spanish mackerel (*Scomberomorus maculatus*).

Fig. 233.—Dorsal view, life; actual length 2 mm.
Fig. 234.—Ventral view of another specimen, life.

*Gasterostomum arcuatum* Linton, from cero (*Scomberomorus regalis*).

Fig. 235.—Lateral view, life; actual length 4.2 mm.

## PLATE XXXIII.

*Gasterostomum gracilescens* Rudolphi.

Fig. 236.—From silverside (*Menidia menidia*), encysted. (See Figs. 230–232.) Cyst filled with material that resembled small fat globules and an immature *Gasterostomum*. Actual length of cyst 1.5 mm. *i*, Rudiment of intestine.
Fig. 237.—From flounder (*Paralichthys albiguttus*); dorsal view. Life; actual length 1.28 mm.
Fig. 238.—From toad-fish (*Opsanus tau*). Immature specimen. Life; actual length 0.9 mm.
Fig. 239.—Another specimen from same lot.

*Gasterostomum gorgon*, sp. nov., from amber jack (*Seriola lalandi*).

Fig. 240.—Sketch of specimen killed in formalin, tentacles extended. Actual length 1.65 mm., diameter of neck 0.21 mm.
Fig. 241.—Another specimen from same lot, with tentacles retracted, the most usual condition in the preserved specimens. Sketch made from specimen in balsam, somewhat diagrammatic. Actual length 0.6 mm.
Fig. 242.—Ova of same. Length of ovum 0.022 mm.

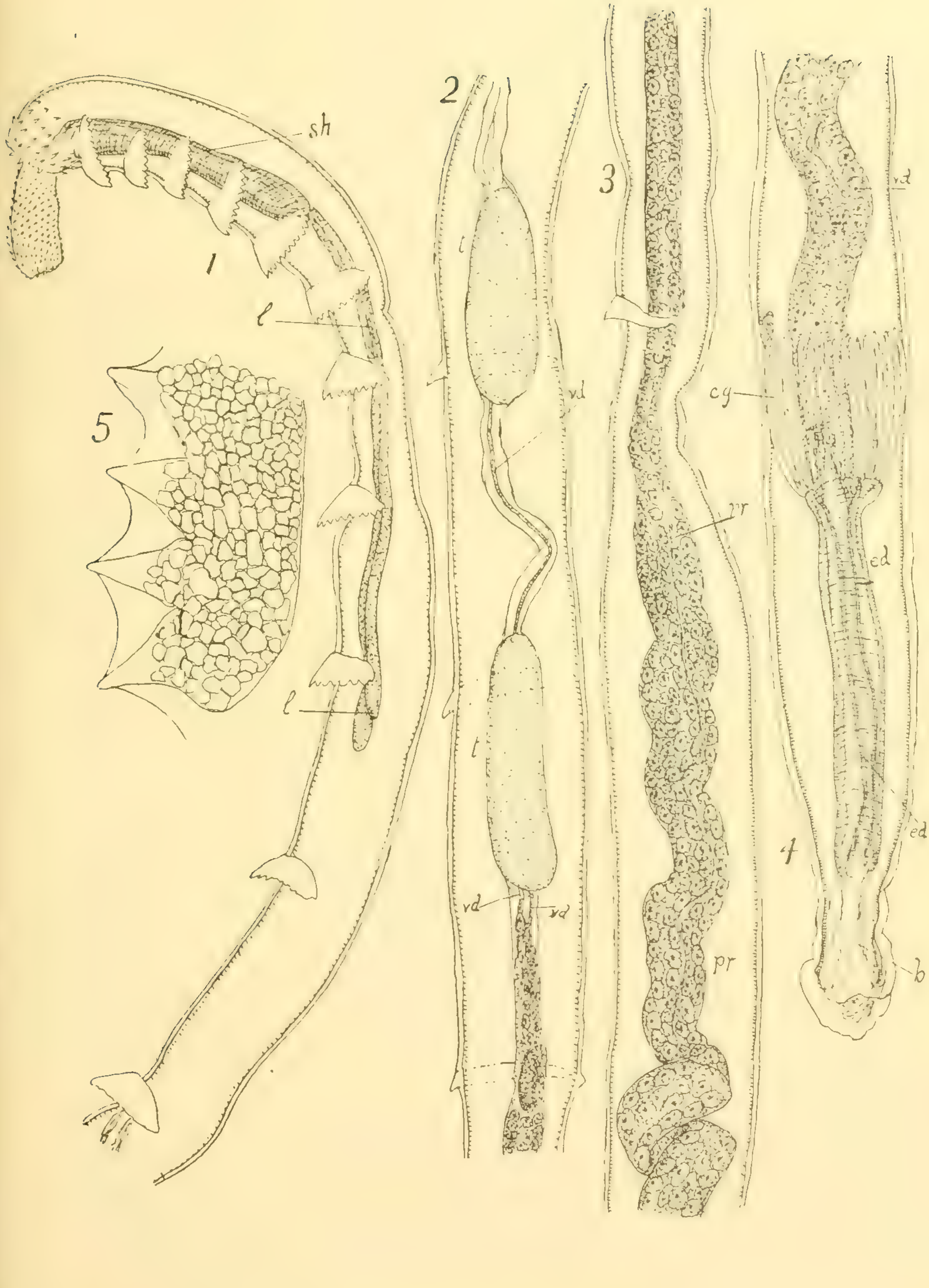
## PLATE XXXIV.

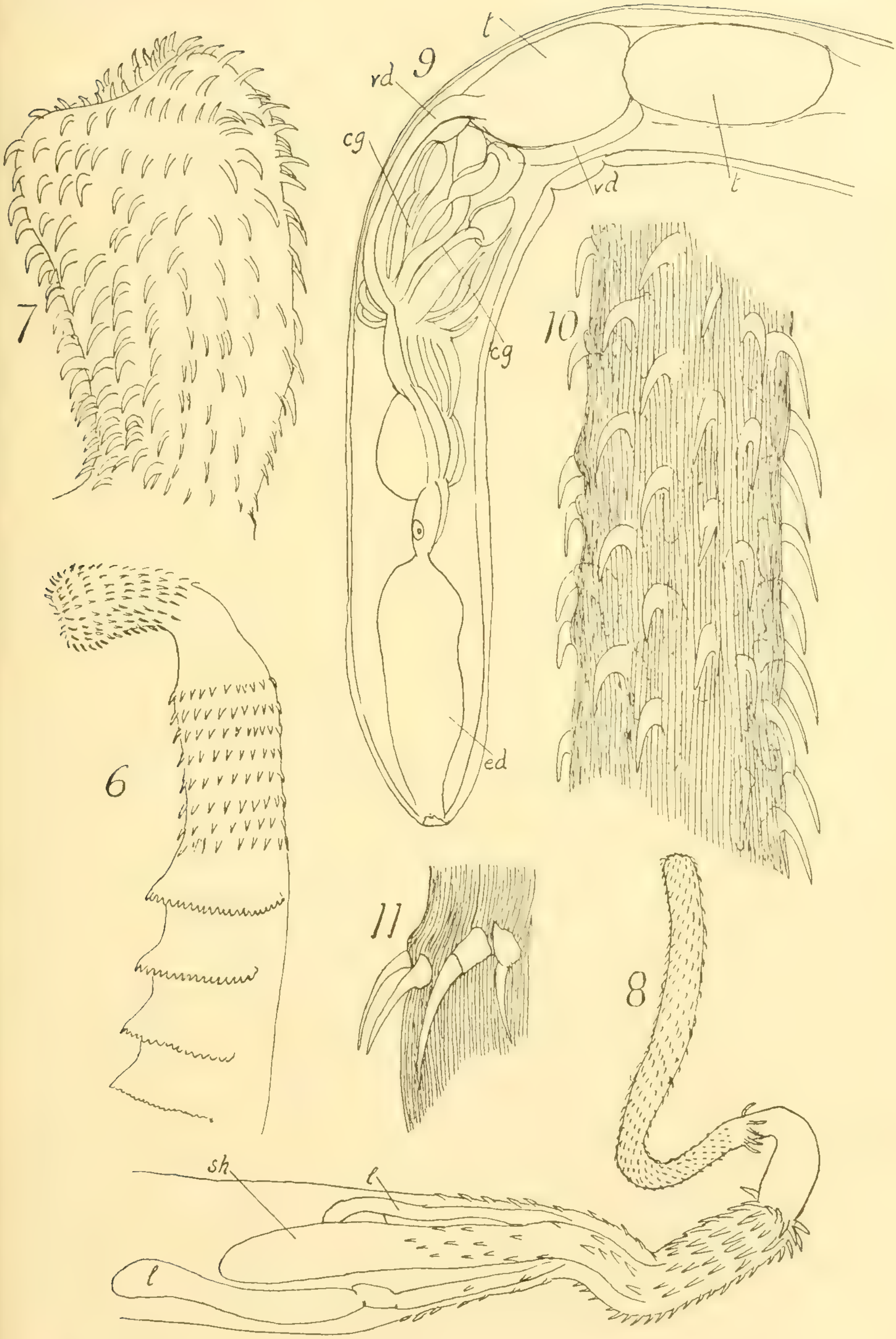
*Aspidogaster ringens*, sp. nov., from croaker (*Micropogon undulatus*).

Fig. 243.—Lateral view. Actual length about 2 mm. There is great variation in this species with different states of contraction; for example, the head may be retracted, or head and tail both retracted until the body proper is shorter than the ventral sucker.
Fig. 244.—Dorsal view of a specimen the actual length of which was 1.5 mm., life.
Fig. 245.—Dorsal view of living specimen, compressed. × 50.
Fig. 246.—Ventral view of alcoholic specimen. Actual length 1.8 mm.
Fig. 247.—Ventral view of head and neck of living specimen, ventral sucker omitted. × 50.
Fig. 248.—Lateral view of posterior end of body of living specimen. × 50. The position of the testis and ovary is variable. In some cases they lie near the middle of the length of the body.
Fig. 249.—Front view of head, alcoholic specimen.

## EXPLANATION OF LETTERS ON PLATES.

| | | | |
|---|---|---|---|
| *bl* | blastocyst. | *od* | diverticulum of œsophagus. |
| [illegible] | cirrus. | *œ* | œsophagus. |
| [illegible] | cirrus pouch. | *ph* | pharynx. |
| [illegible] | cyst. | *pr* | prostate gland. |
| [illegible] | excretory vessel. | *sr* | seminal receptacle. |
| [illegible] | genital aperture. | *sv* | seminal vesicle. |
| [illegible] | intestine. | *t* | testis. |
| [illegible] | diverticulum of intestine. | *u* | uterus. |
| [illegible] | lemniscus. | *v* | vagina. |
| [illegible] | larva. | *vd* | vas deferens. |
| [illegible] | mouth. | *vg* | vitelline gland. |
| [illegible] | ovary. | *vd* | vitelline duct. |


1
sh
l
l
2
t
vd
t
vd
vd
3
pr
pr
4
vd
cg
ed
ed
b
5



7

9

t
rd
cg
rd
t
cg
ed

10

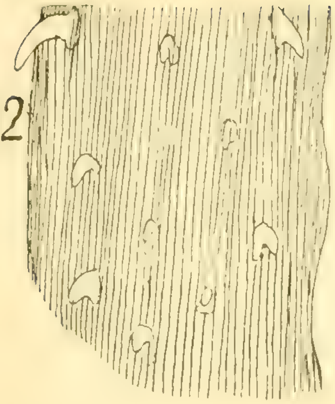
6

11

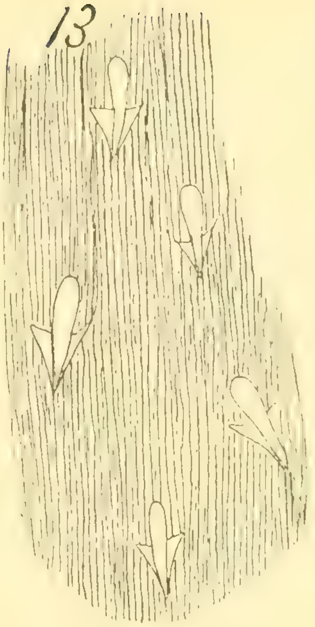
8

sh
l
l

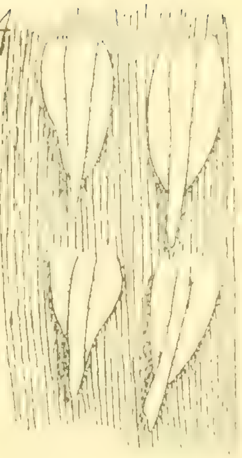
12



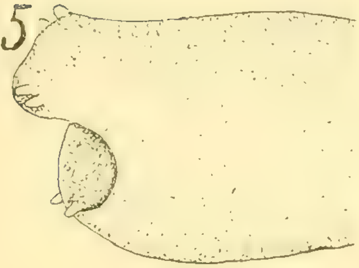
13



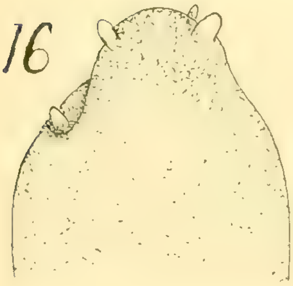
14



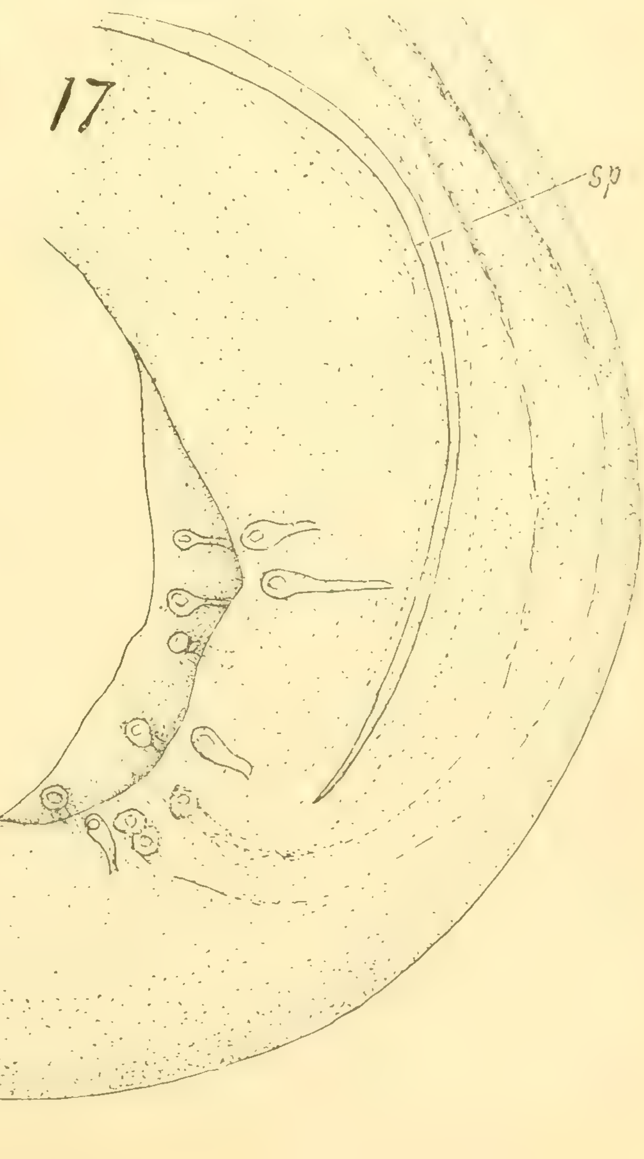
15



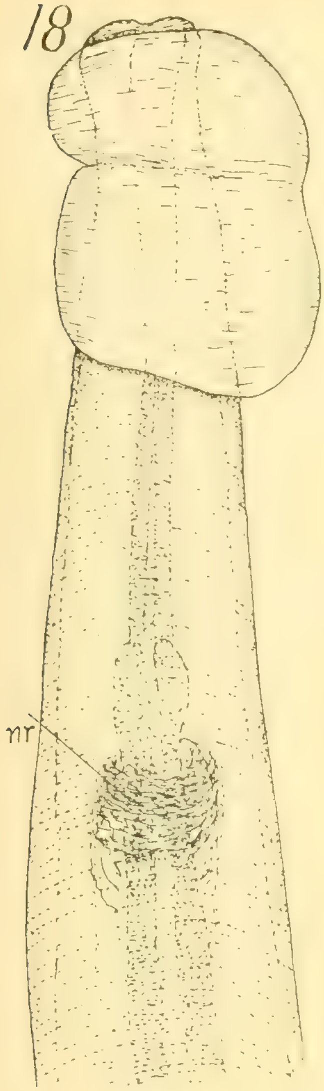
16



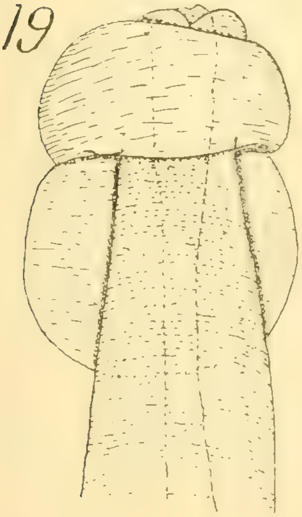
17



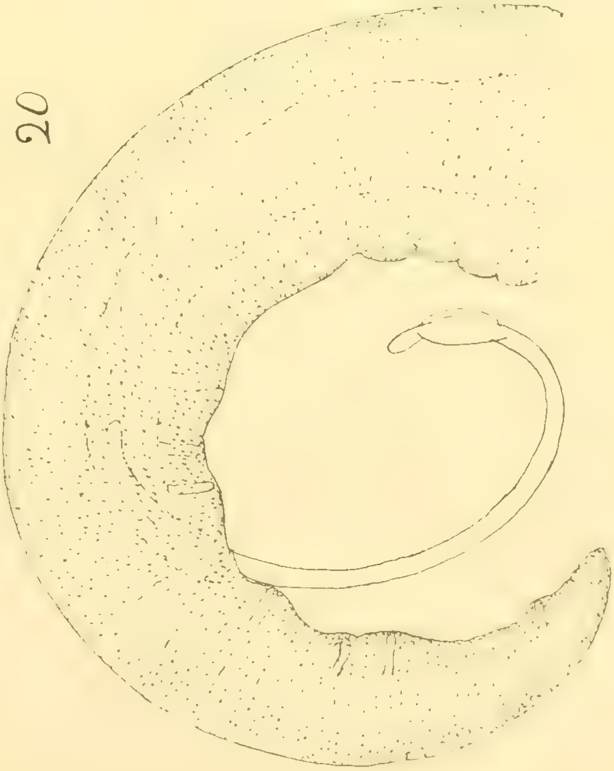
18



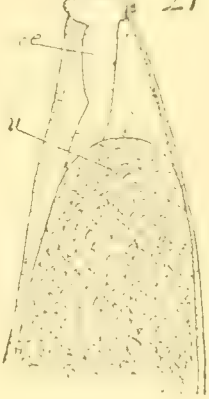
19



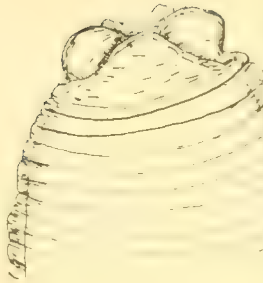
20



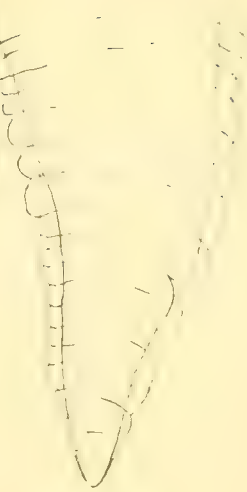
21



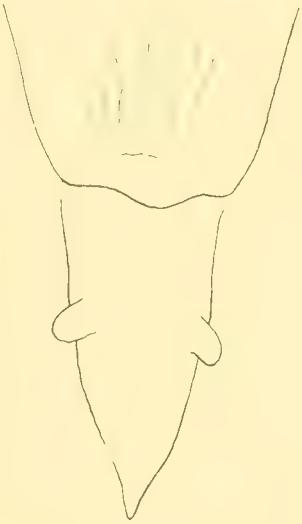
22

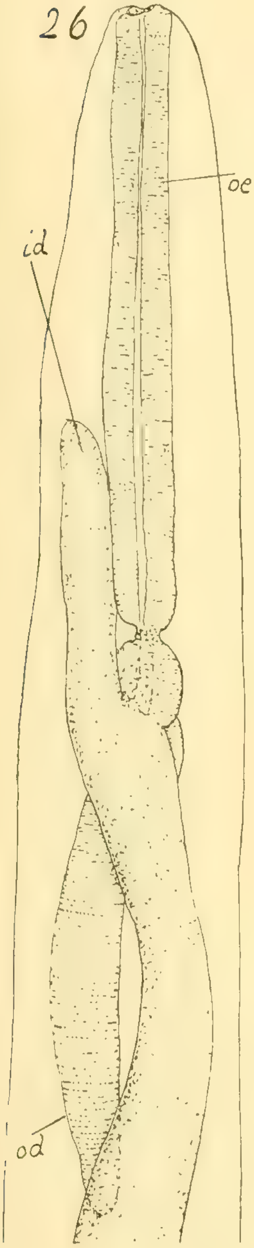


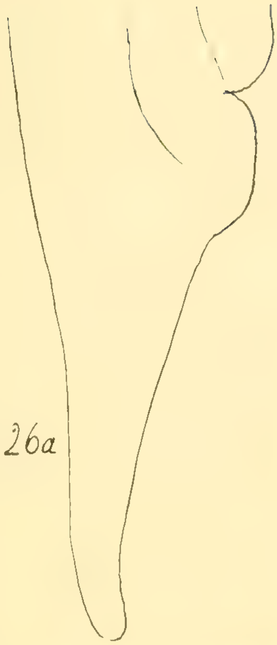
23

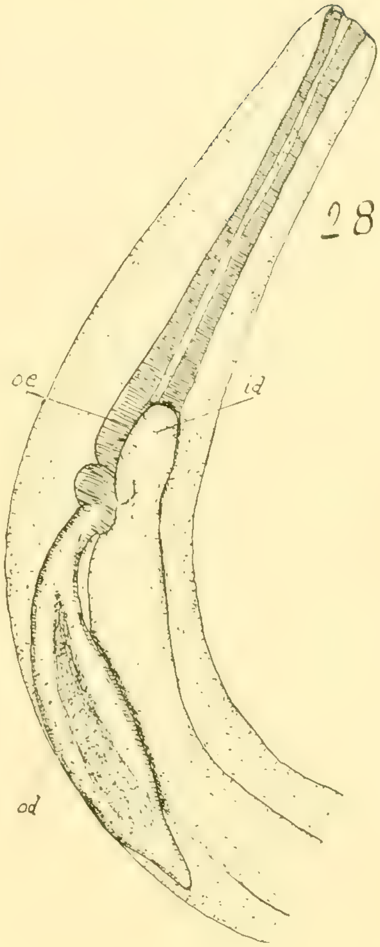


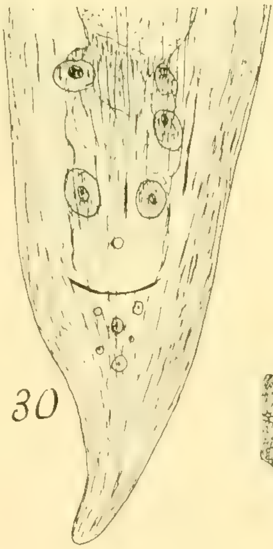
24

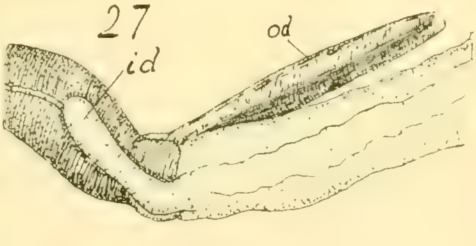


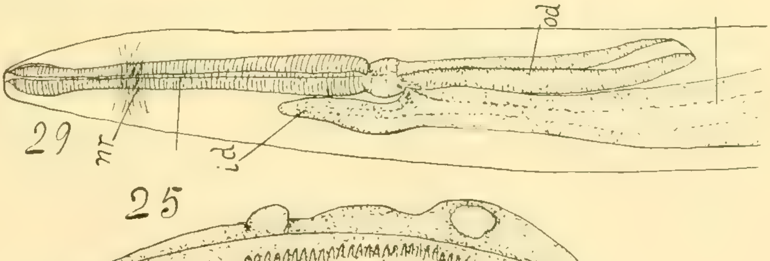

26

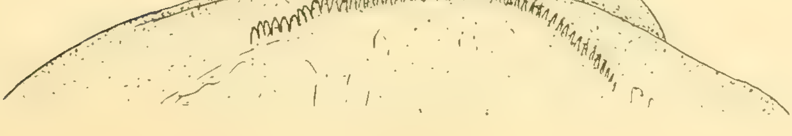

26a

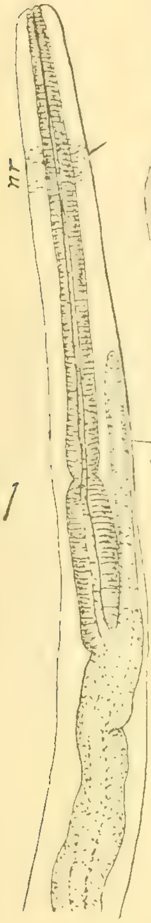

28


30

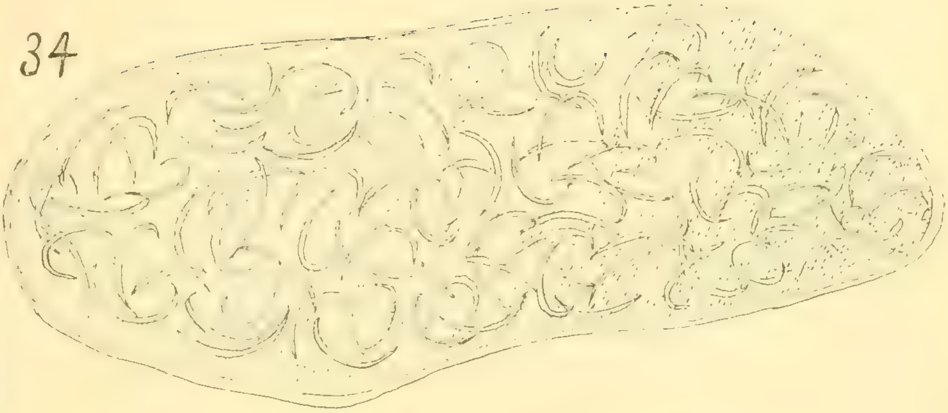

27


29

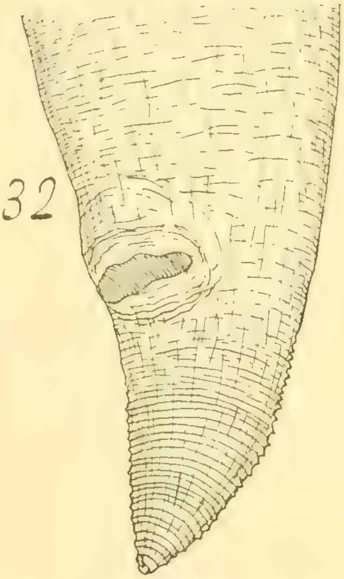

25



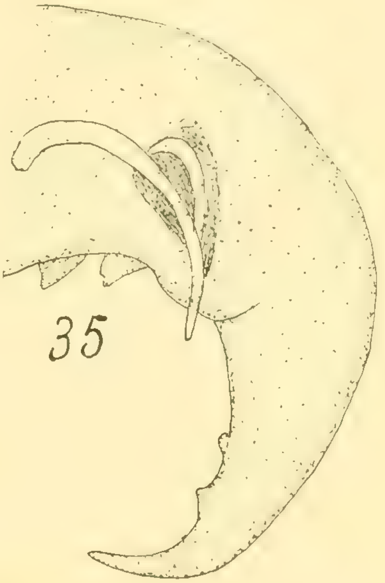
31



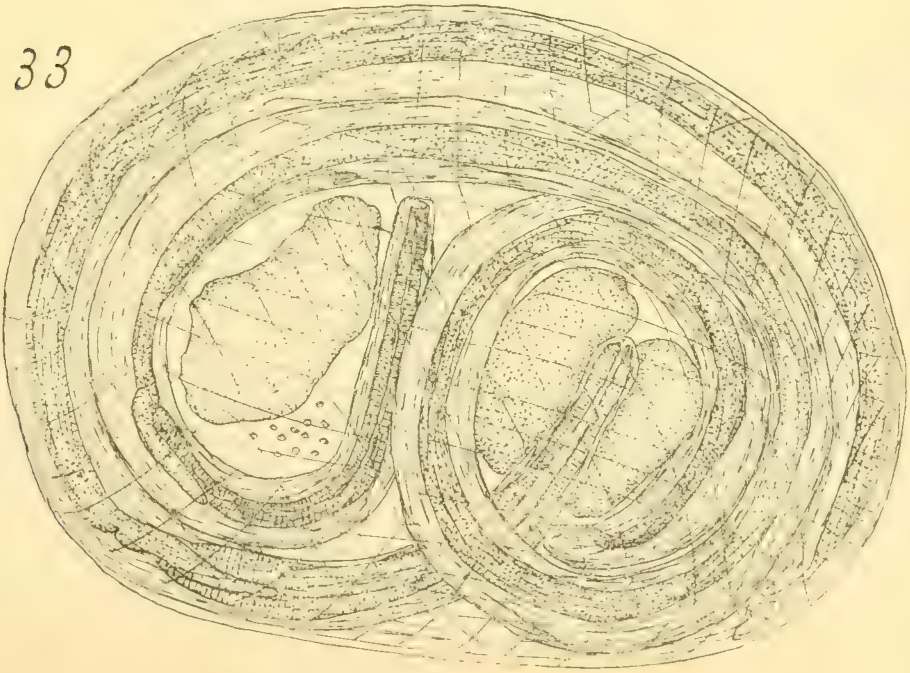
34



32

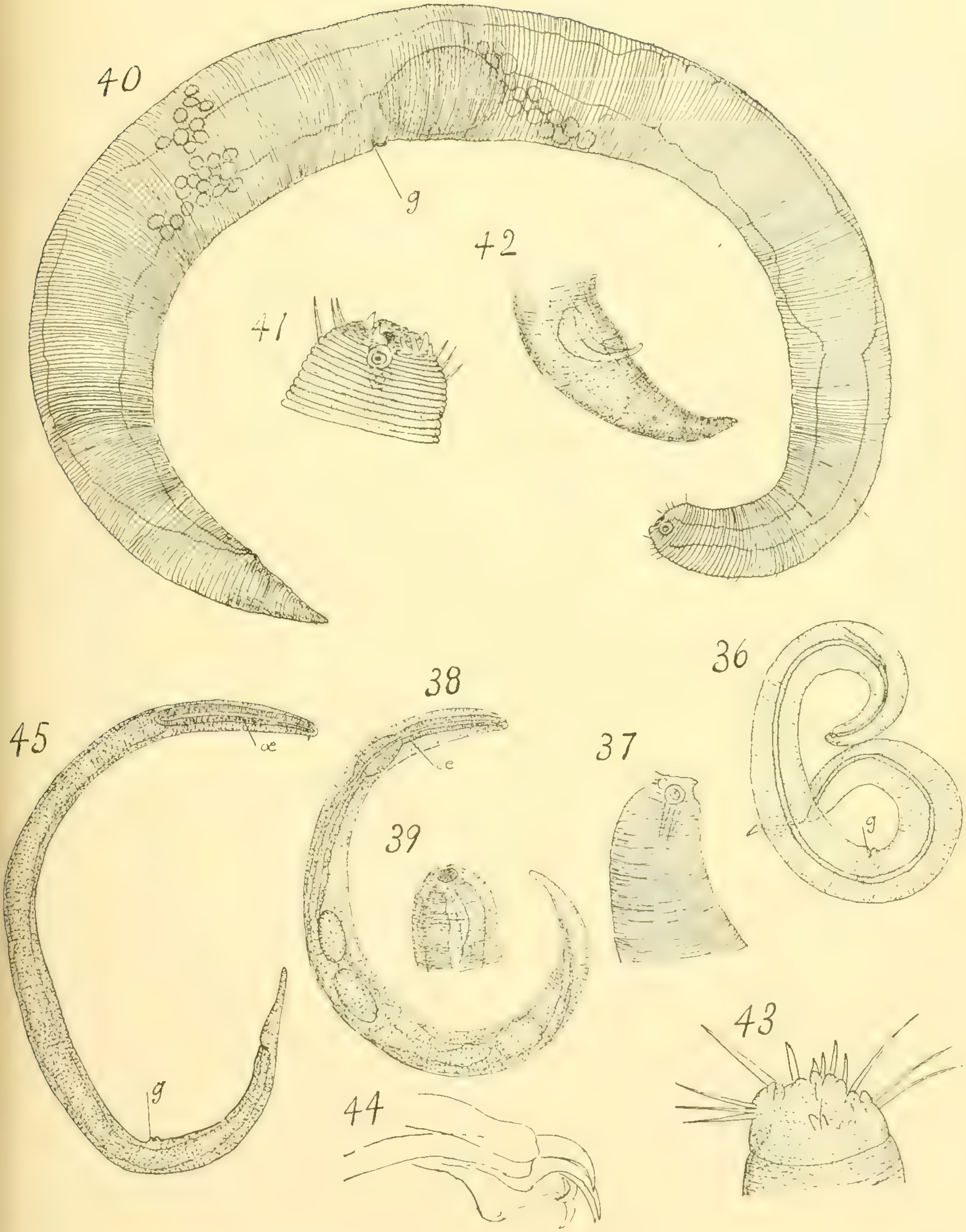


35

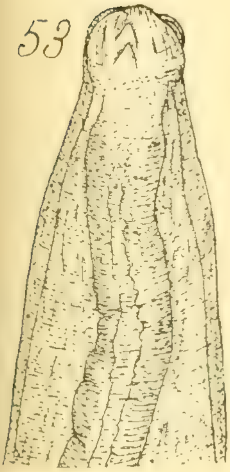


33

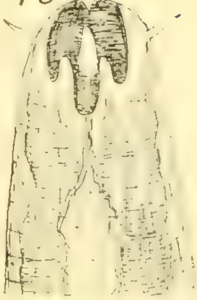
PLATE VII.


40
g
42
41
36
38
45
œ
e
37
g
39
g
43
44

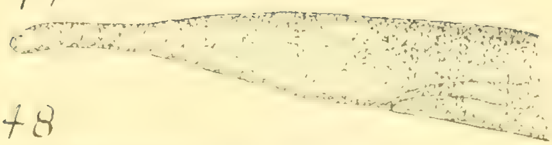
53



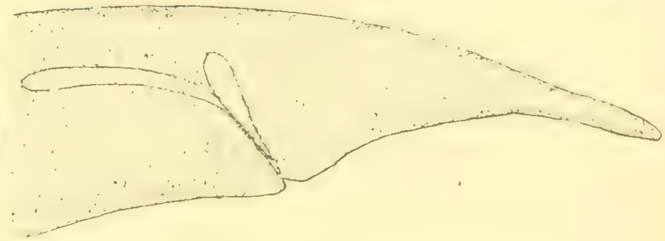
46



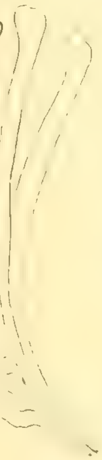
47



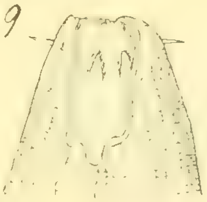
48



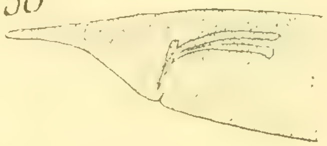
52



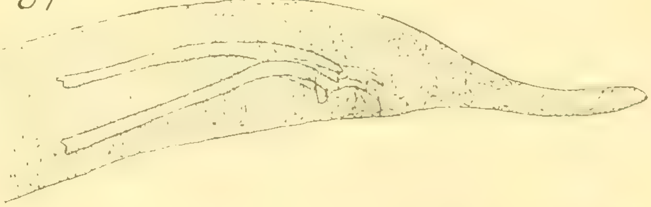
49



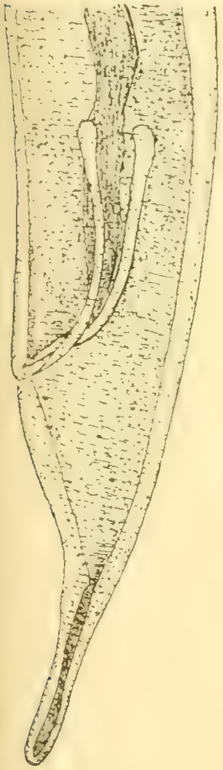
50



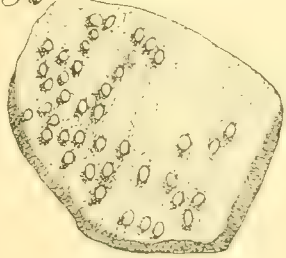
51



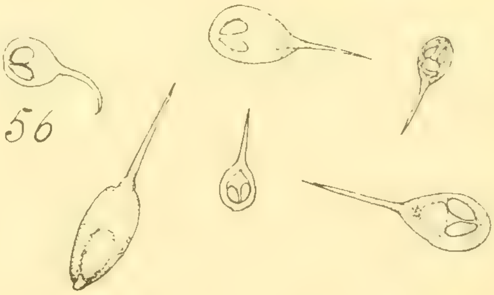
54



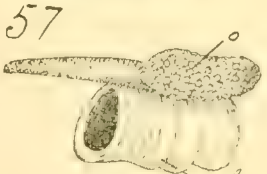
55



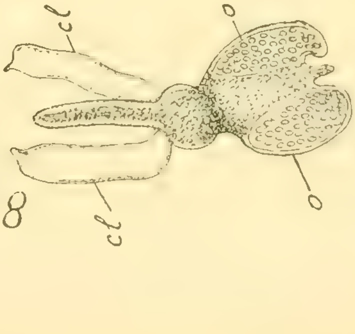
56



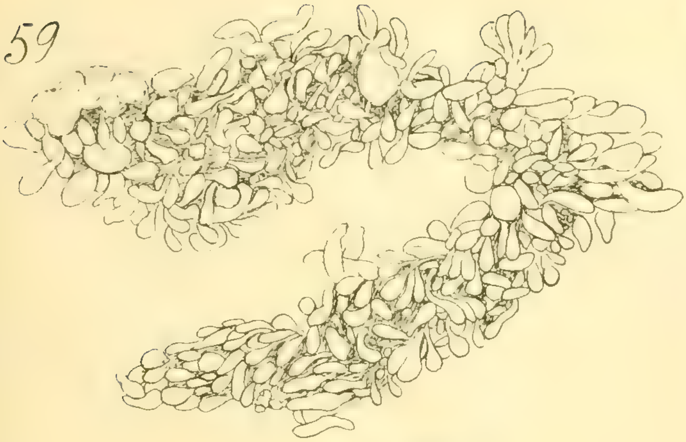
57



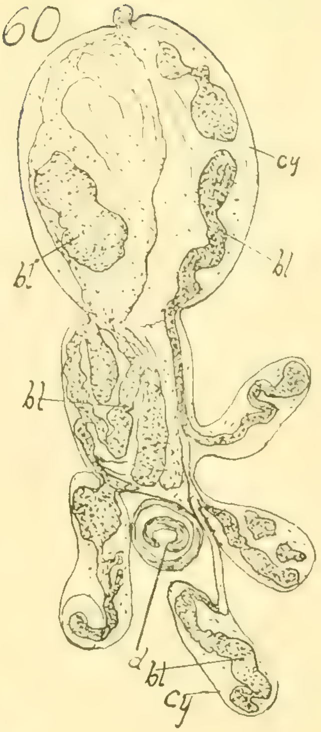
58



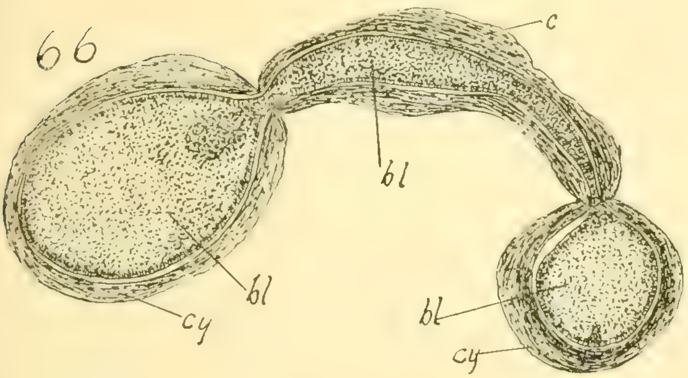
59



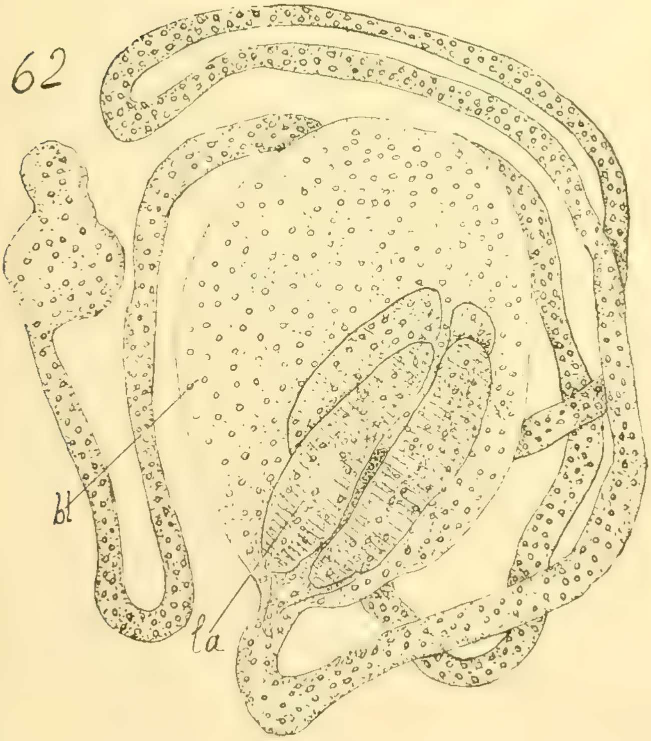
60


cy
bl
bl
bl
d
bl
cy

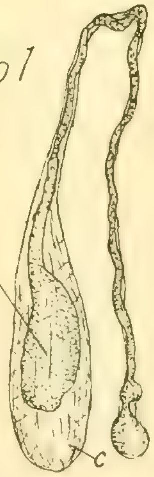
66


c
bl
bl
bl
cy
cy

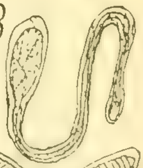
62



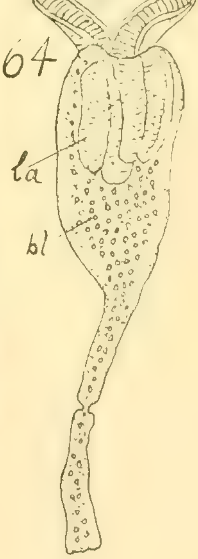
61



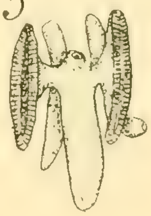
63



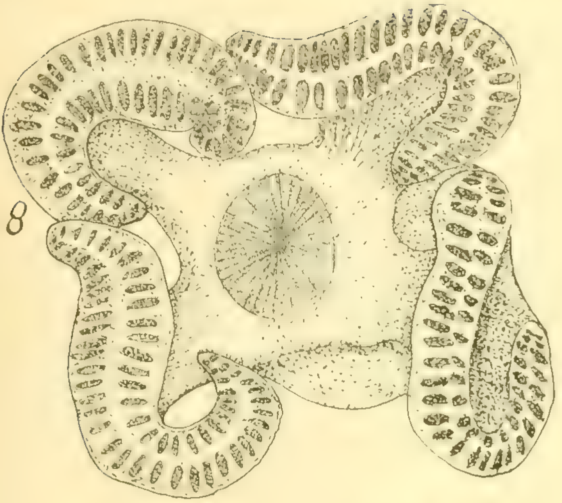
64



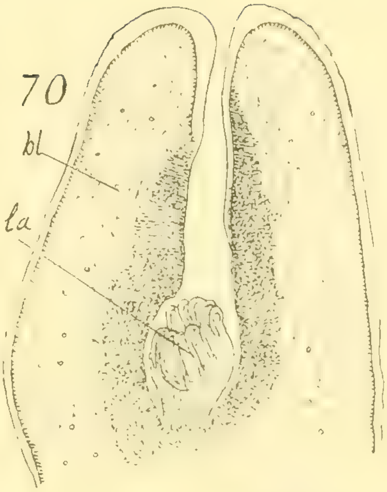
65



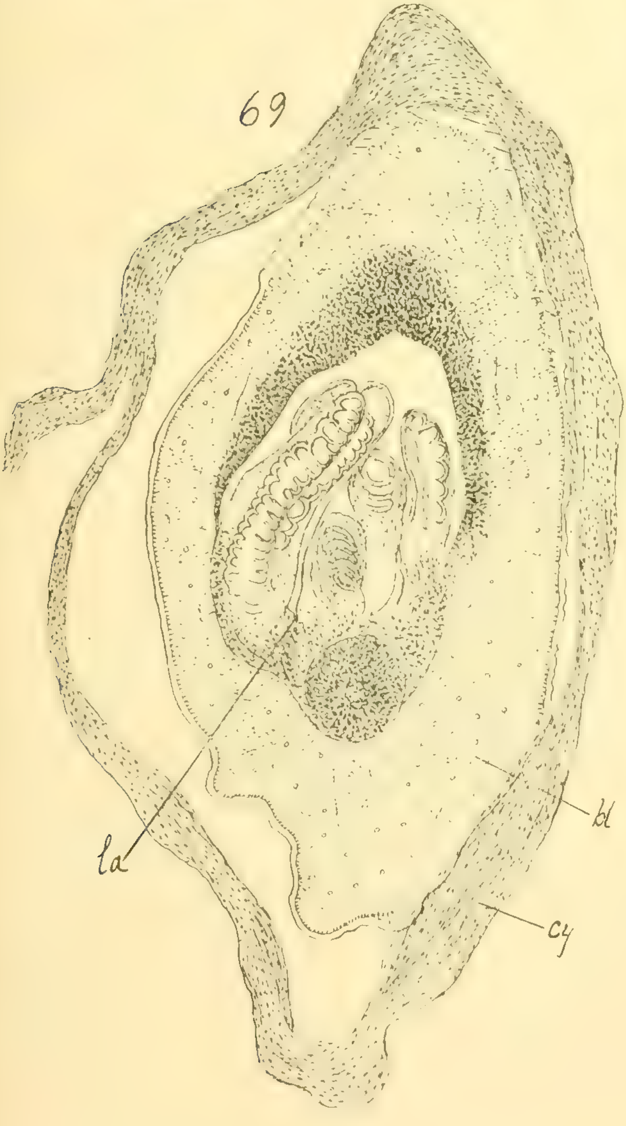
68



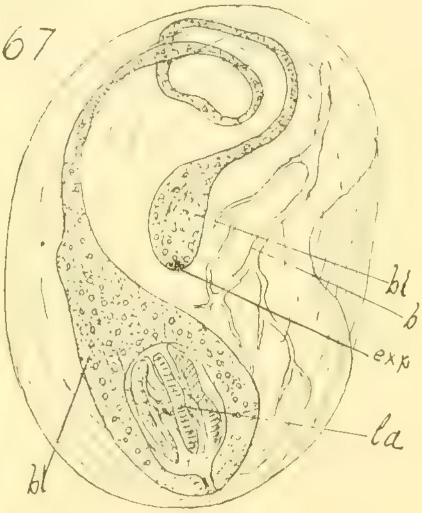
70



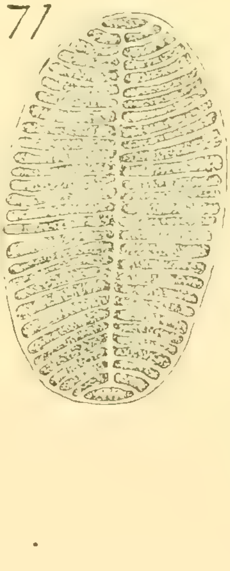
69



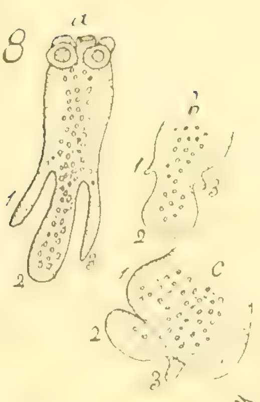
67


bl
b
exp
la
bl

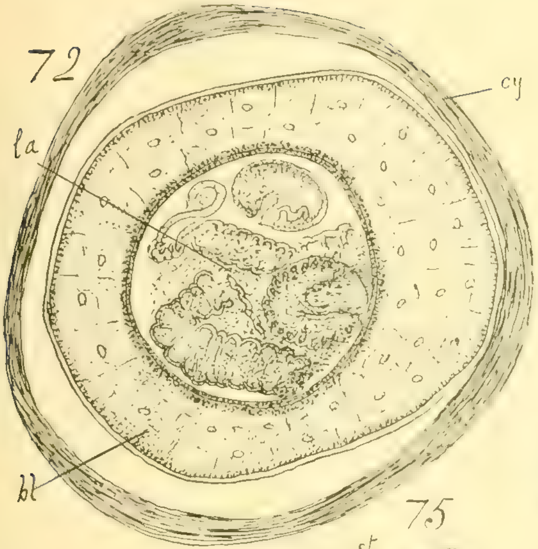
71



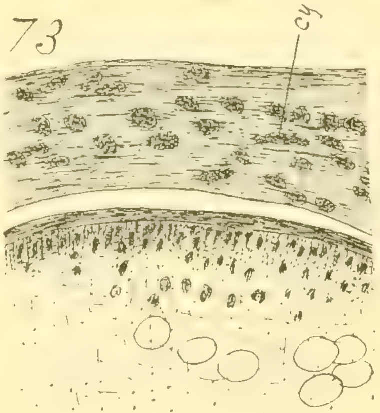
78


a
1
2
b
1
2
3
c
1
2
3

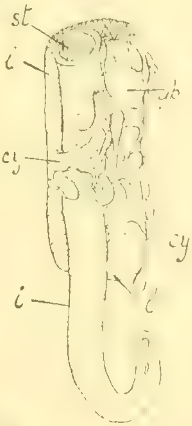
72



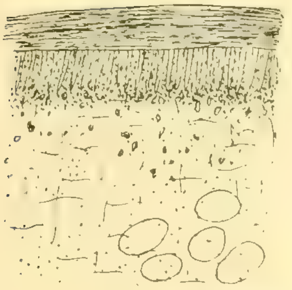
73



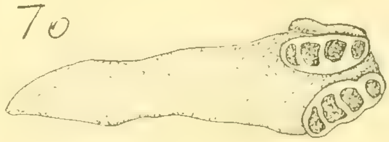
75


st
i
ub
cy
cy
i

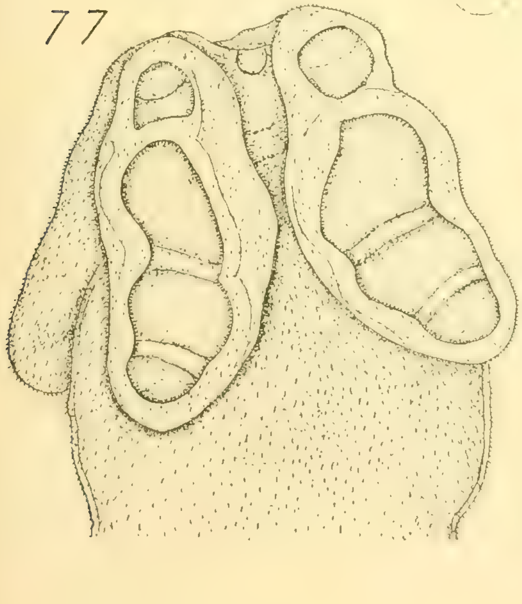
74



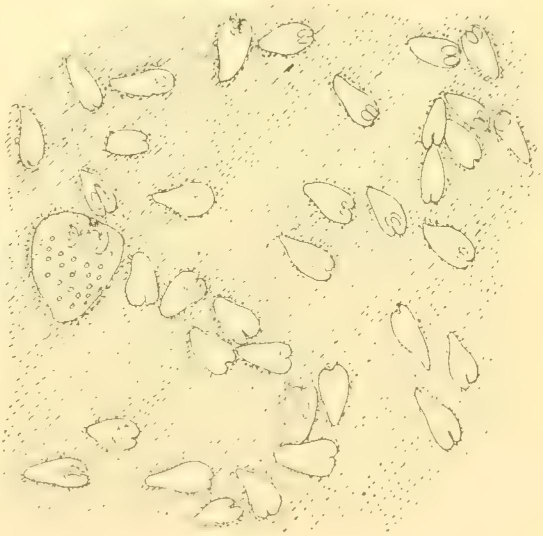
70



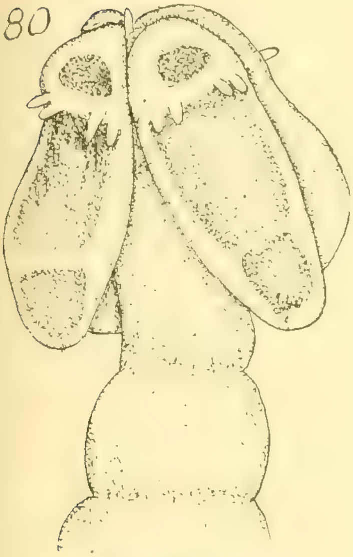
77



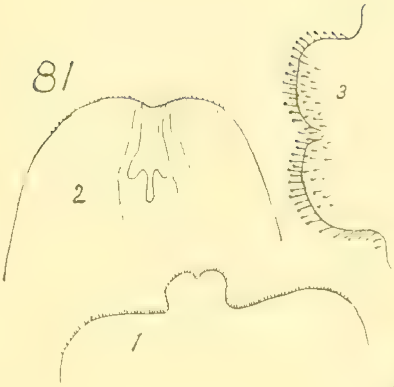
79



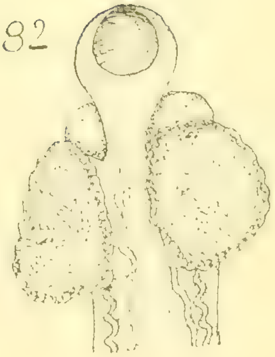
80



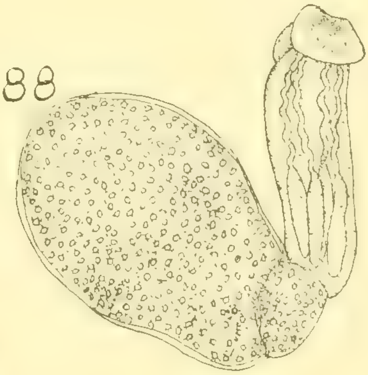
81



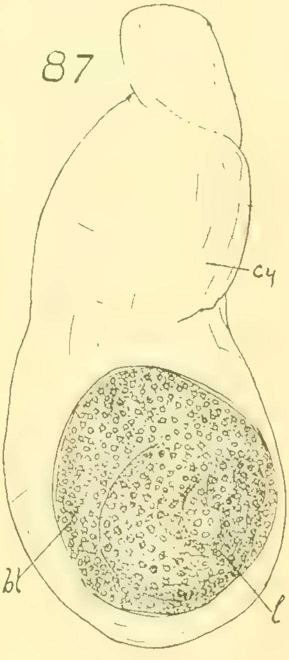
82



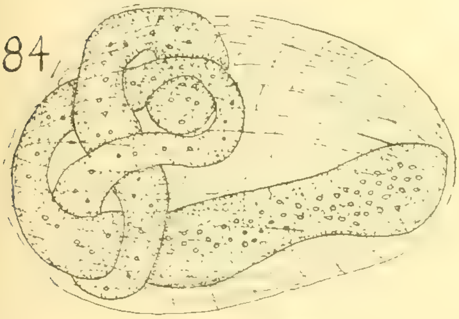
88



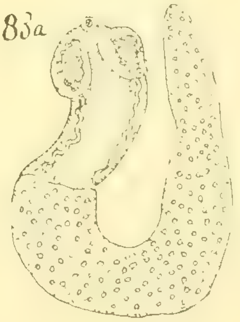
87



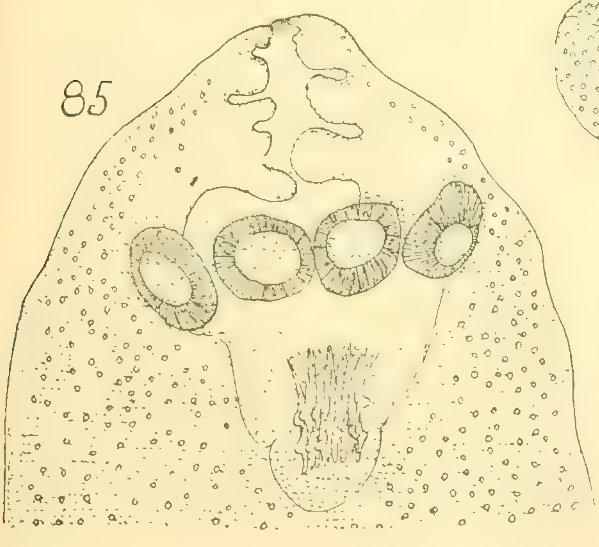
84



85a

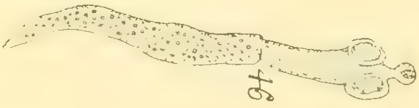


85

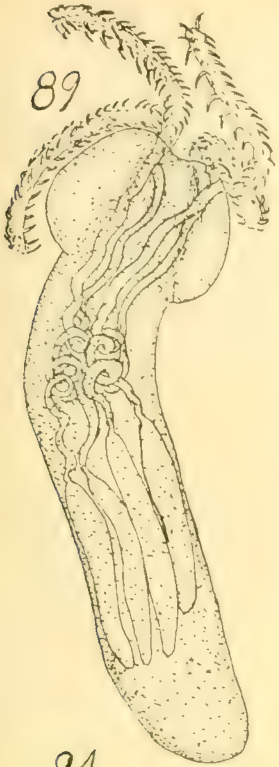


86

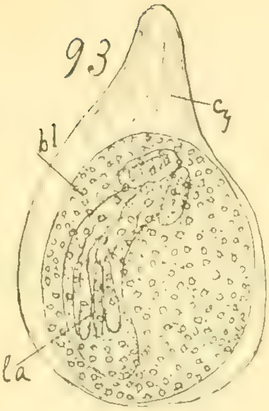
83



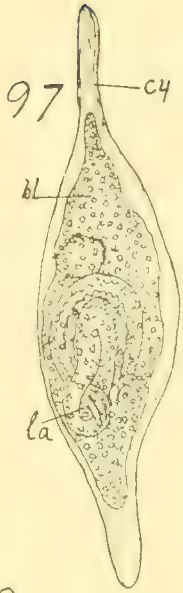
89



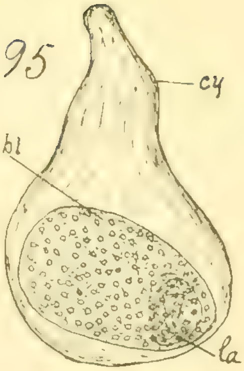
93



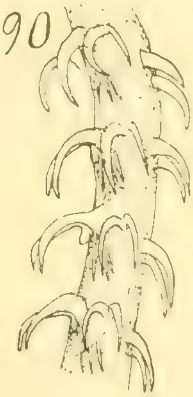
97



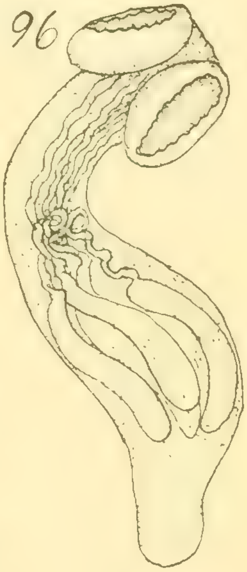
95



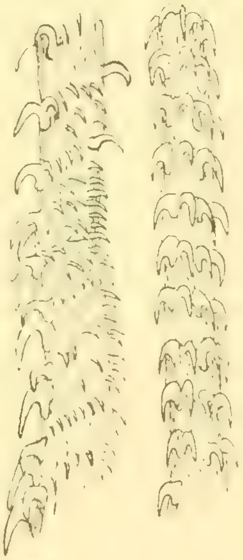
90



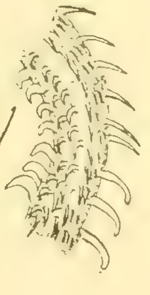
96



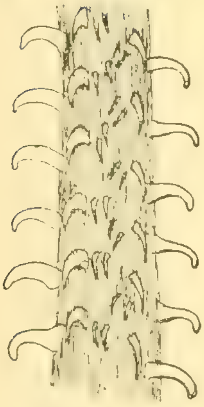
98



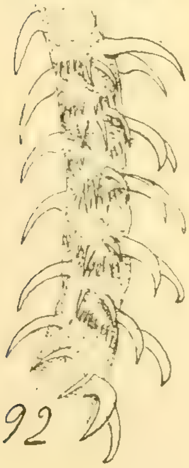
91



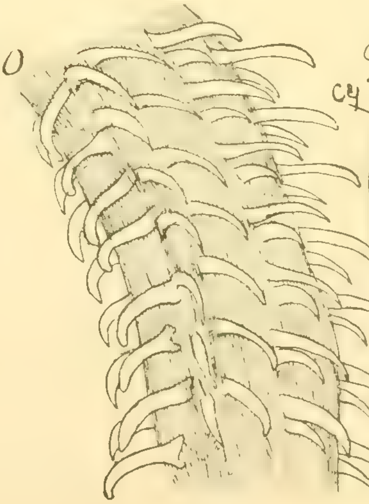
94



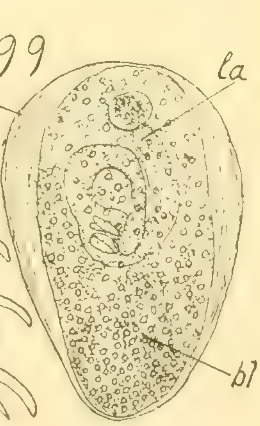
92



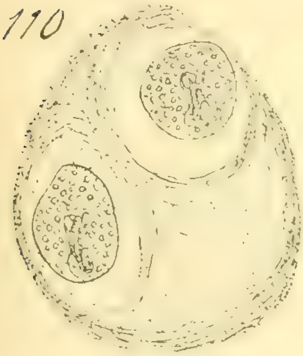
100



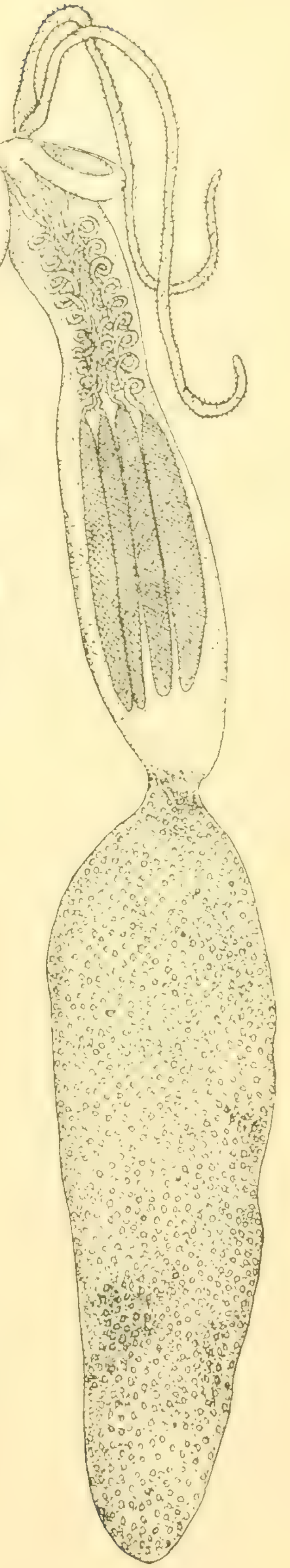
99



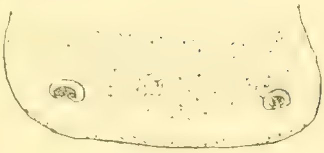
110



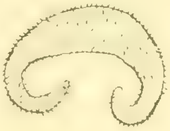
101



108

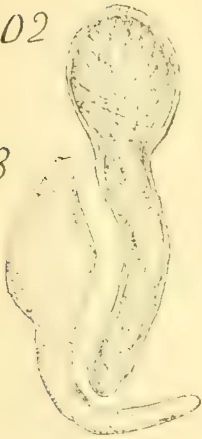


109

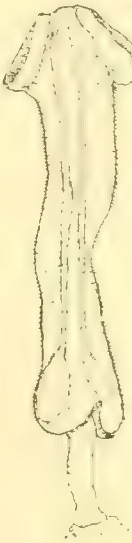


102

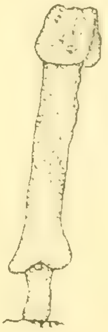
103



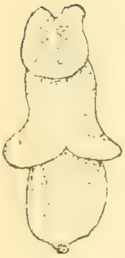
106



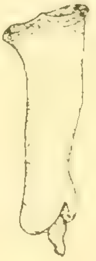
105



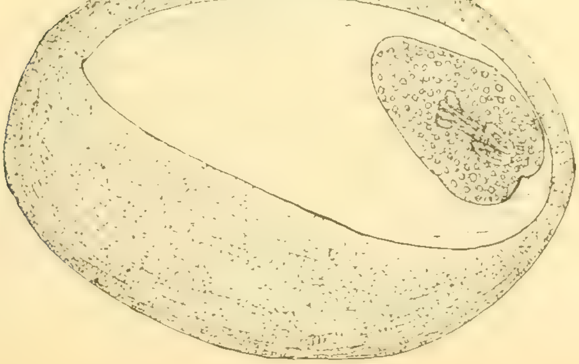
107



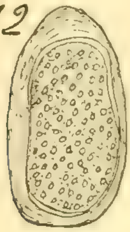
104



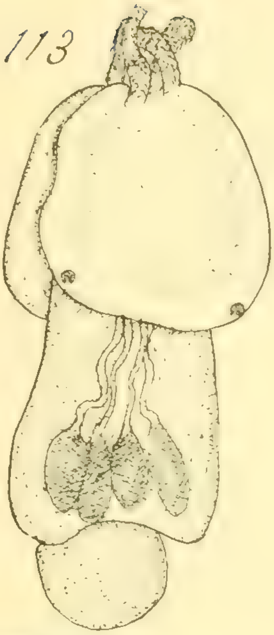
111



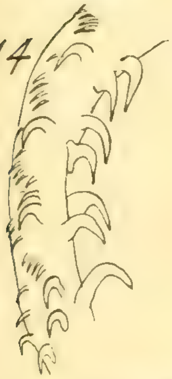
112



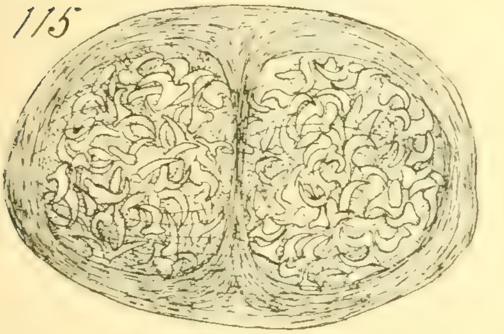
113



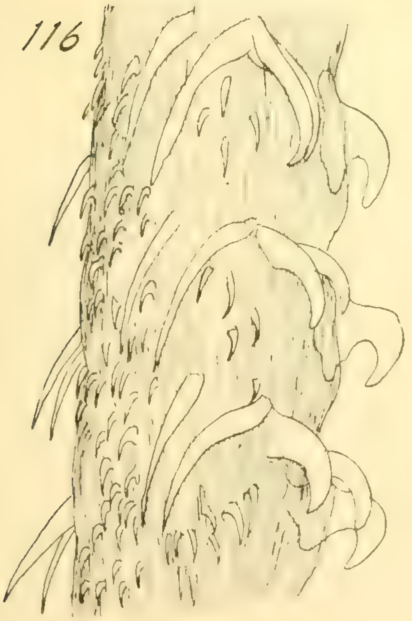
114



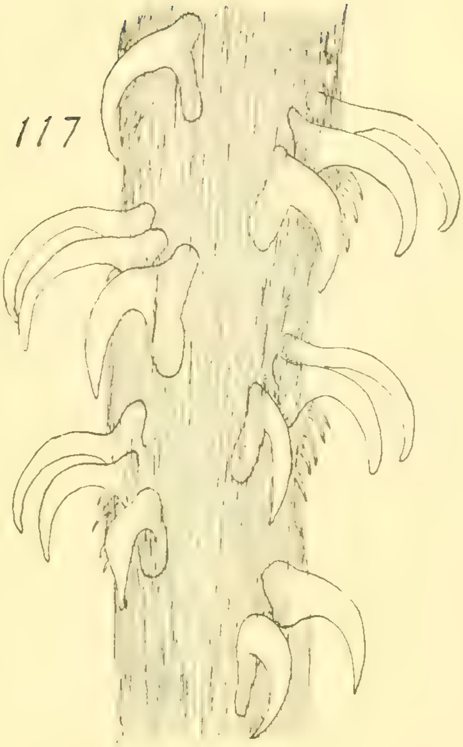
115



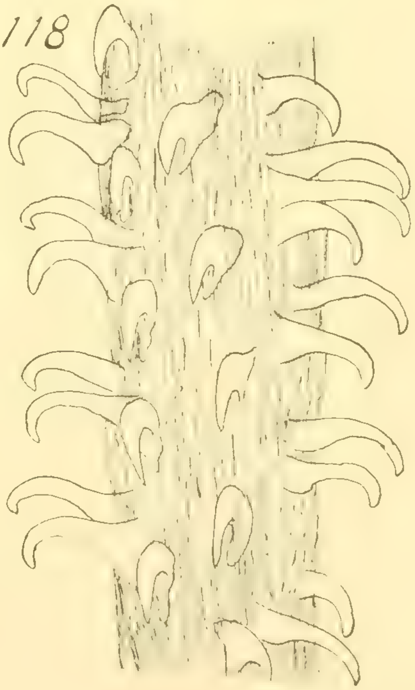
116



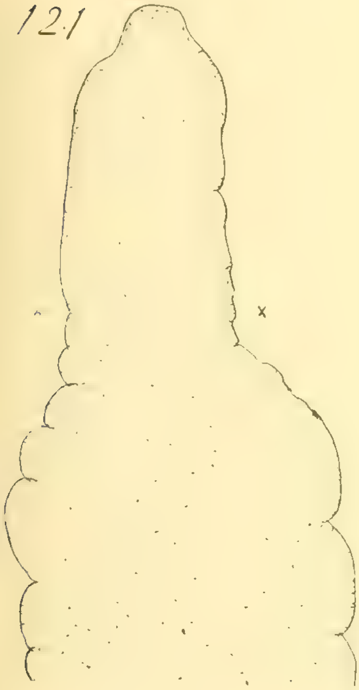
117



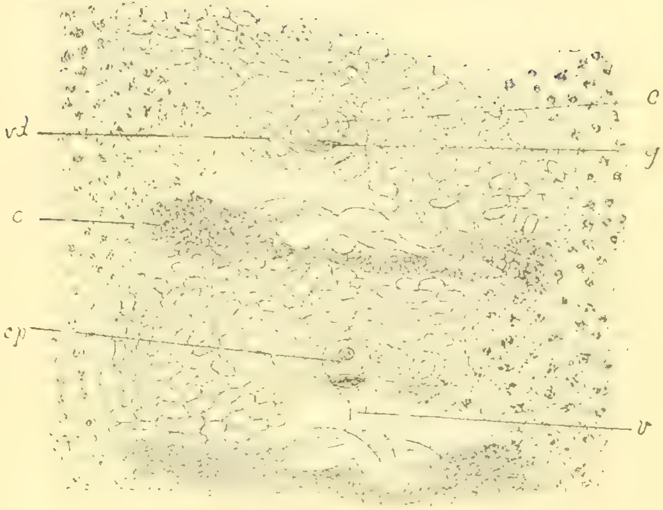
118



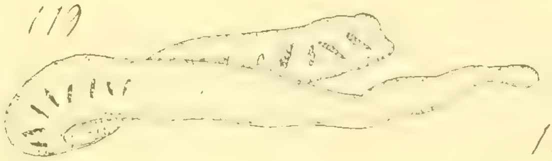
121



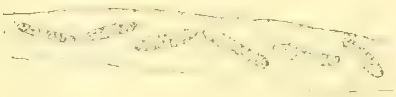
124



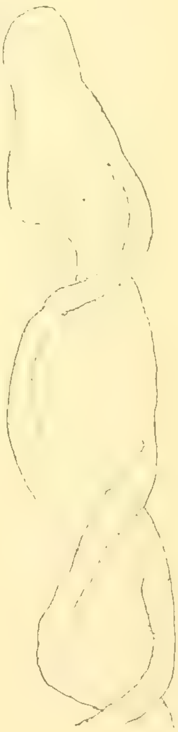
119



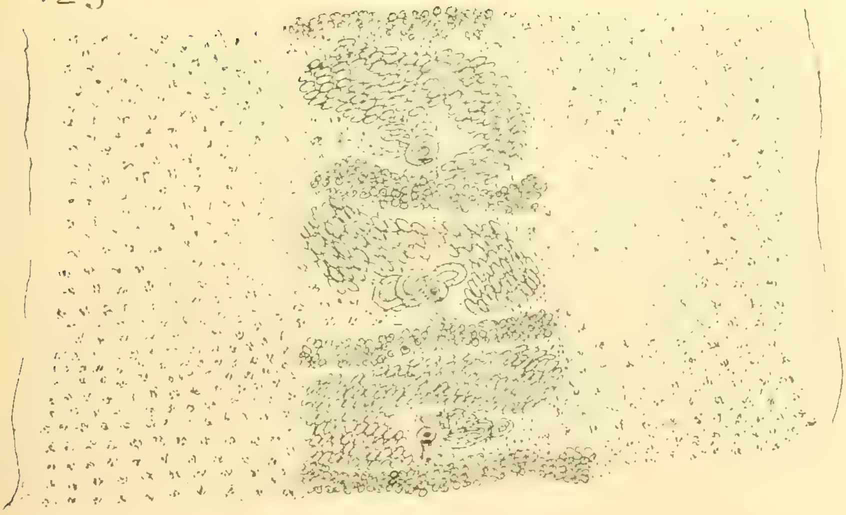
120



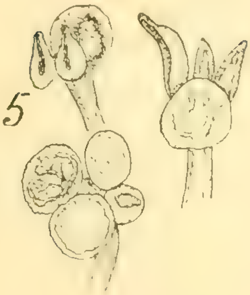
122



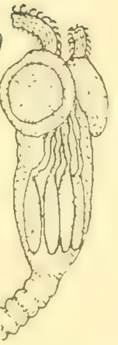
123



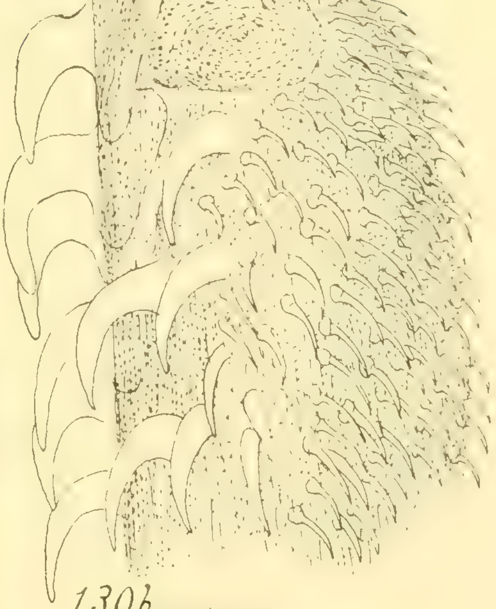
125



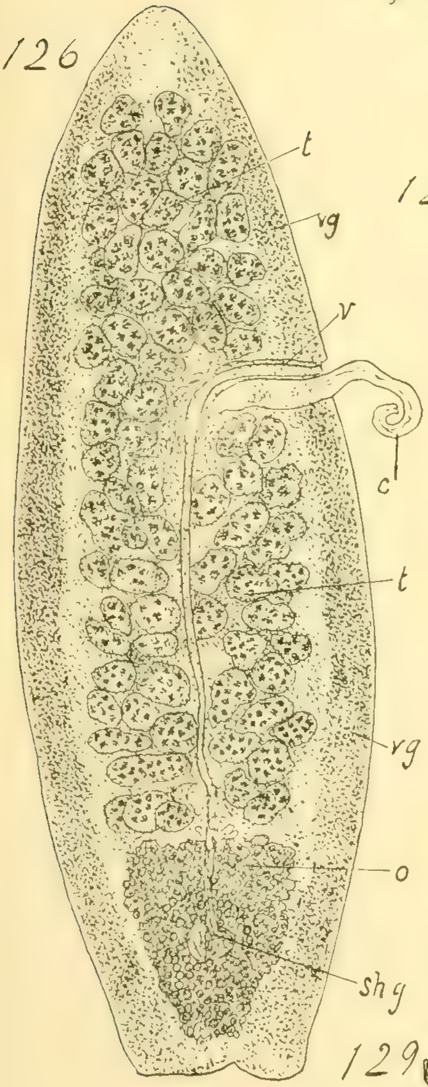
130



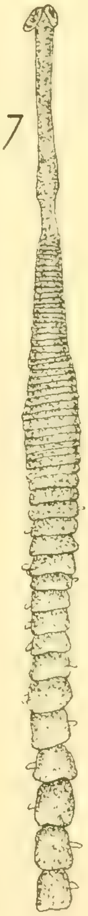
130a



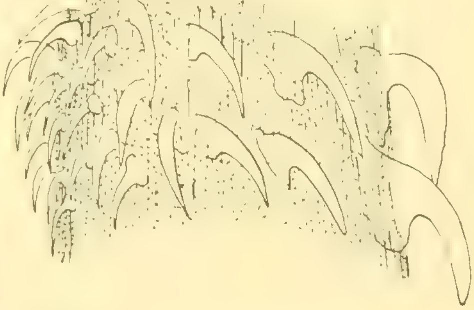
126


t
vg
v
c
t
vg
o
shg

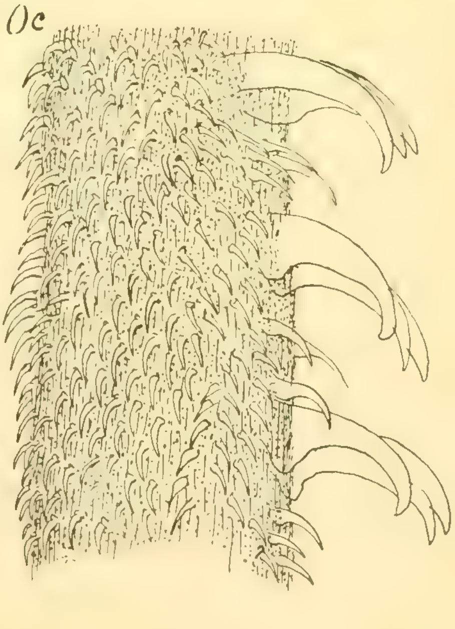
127



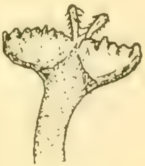
130b



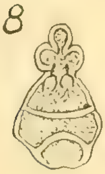
130c



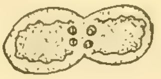
129

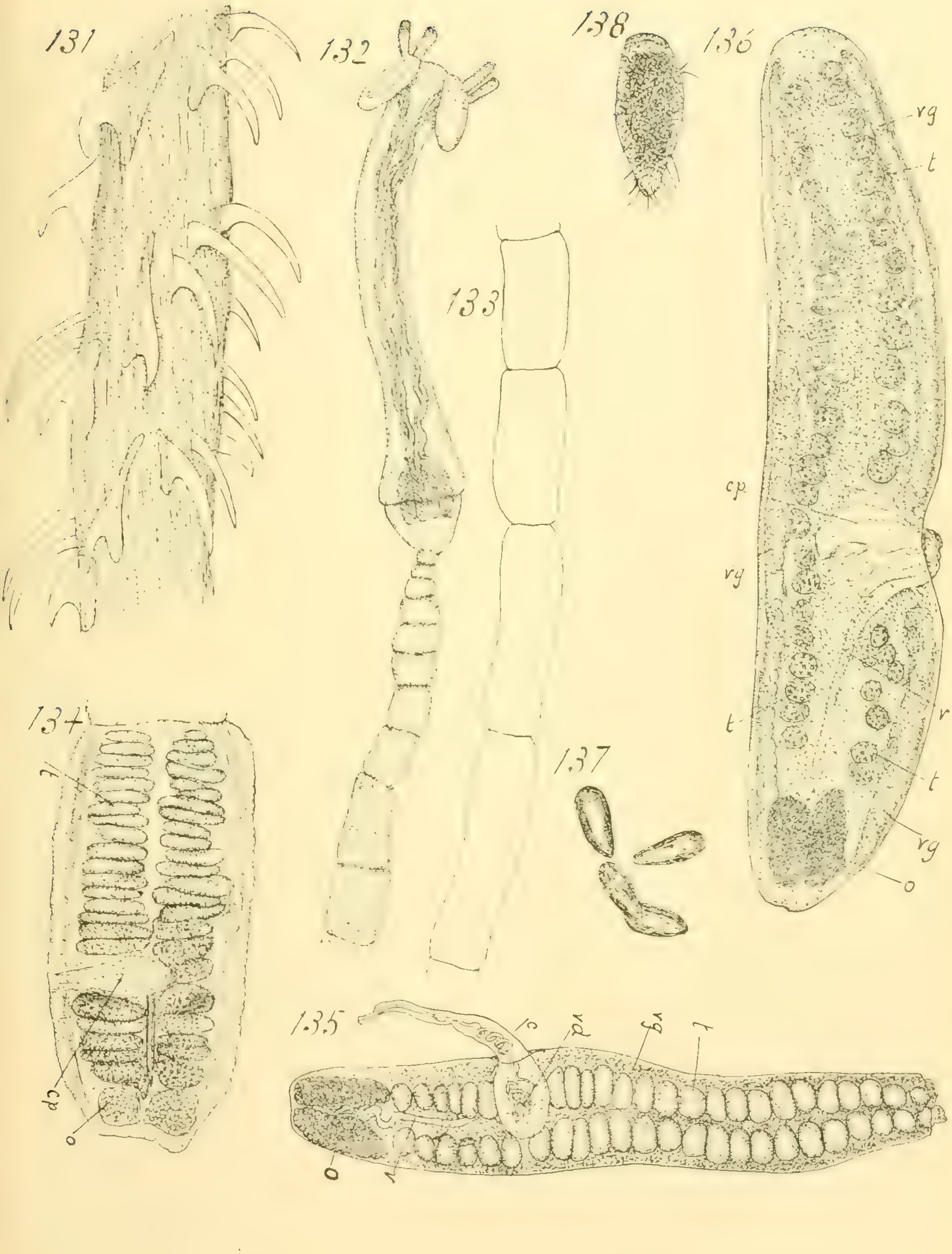


128

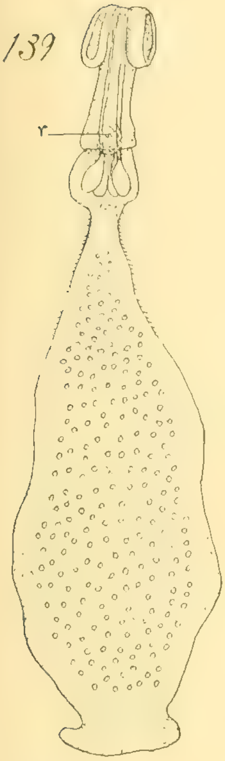


129a

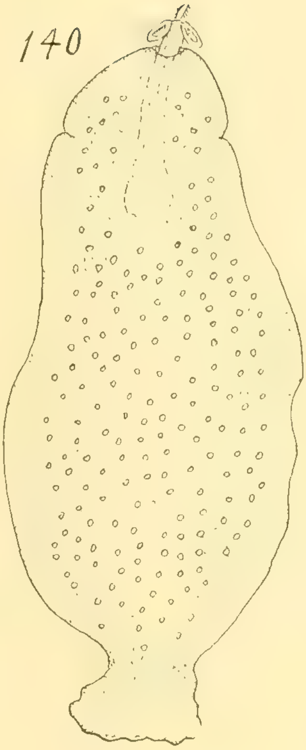



131
v
132
133
138
136
vg
t
cp
vg
t
v
t
vg
o
134
v
cp
o
137
135
c
pd
vg
v
o
v

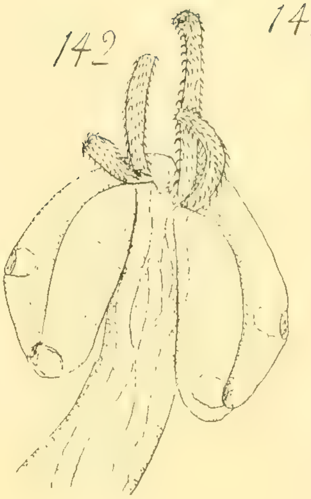
139



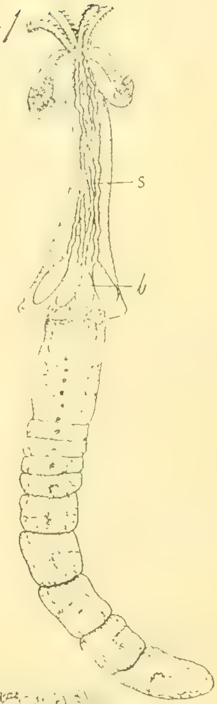
140



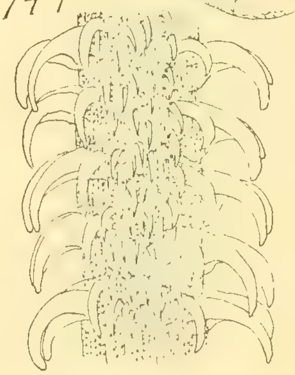
142



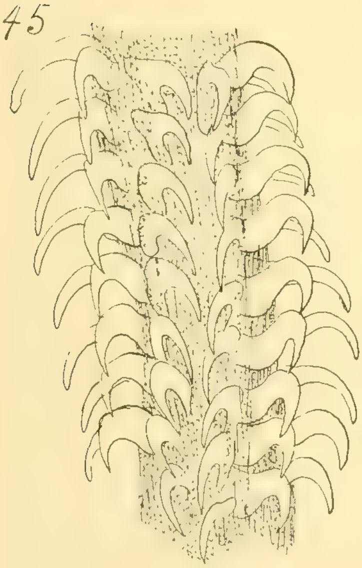
141



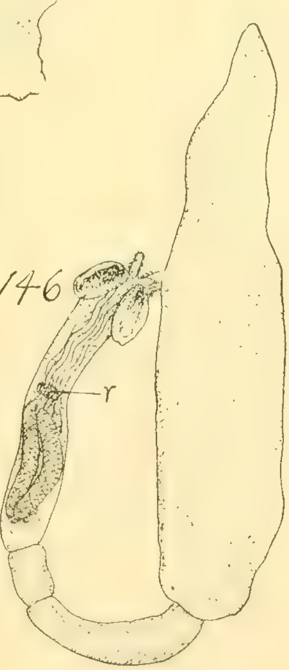
144



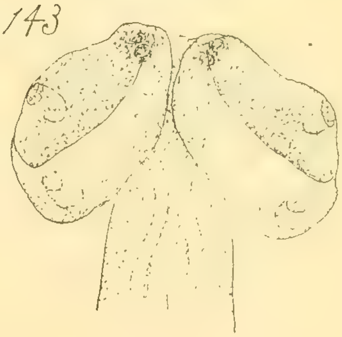
145



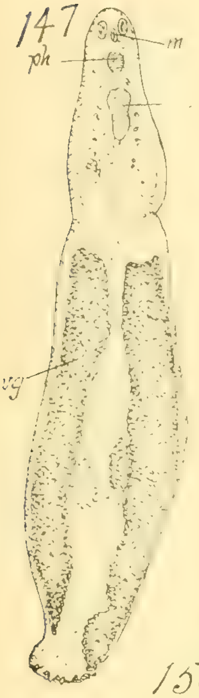
146



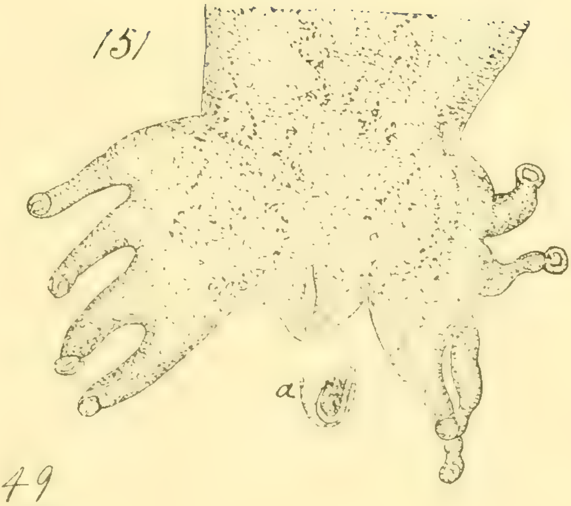
143



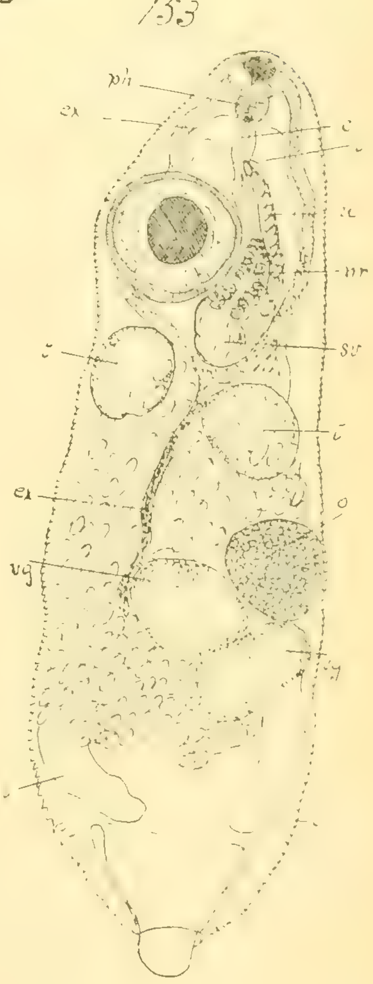
147



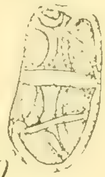
151



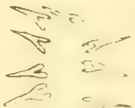
153


ph
ex
c
i
u
nr
sv
t
i
ex
o
vg
i

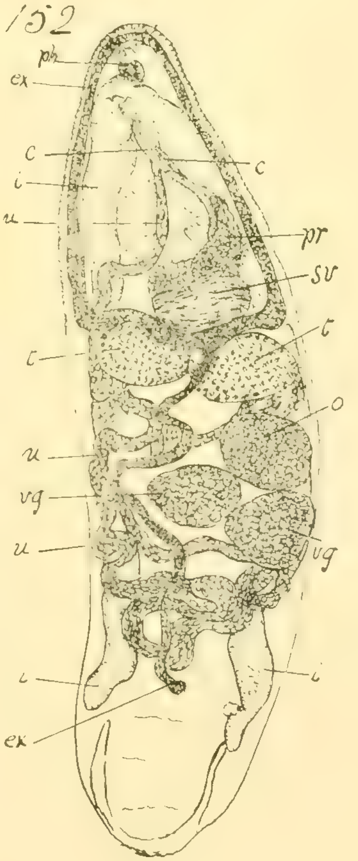
149



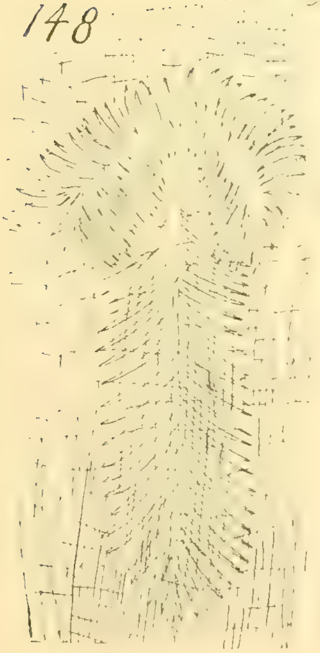
150



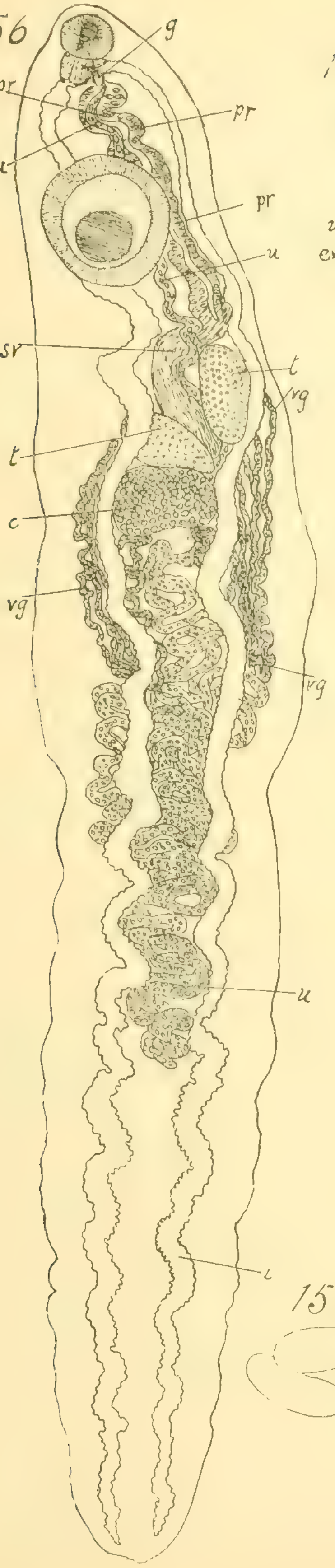
152


ph
ex
c
c
i
u
pr
sv
t
t
o
u
vg
u
vg
i
i
ex

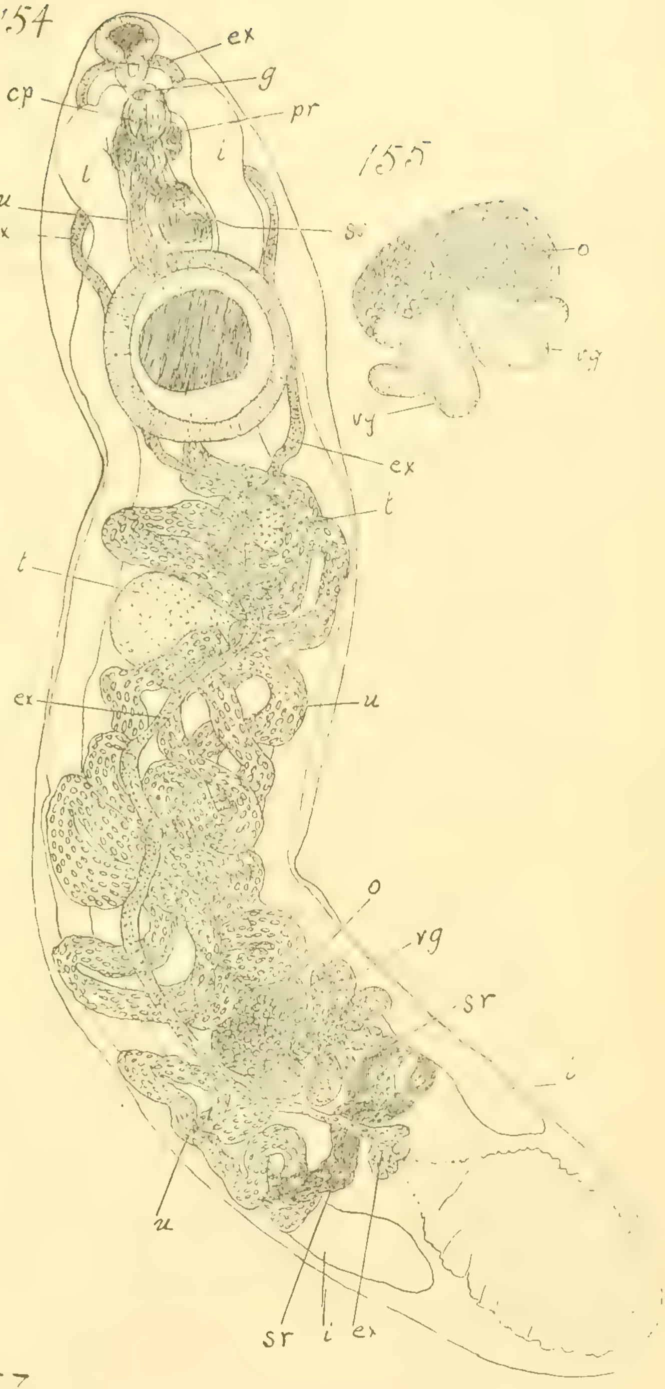
148



156


g
pr
pr
u
pr
u
sr
t
vg
t
c
vg
vg
u
i

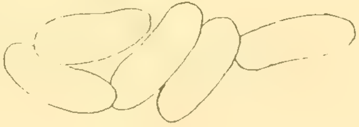
154


ex
g
cp
pr
i
i
u
ex
s
ex
t
t
ex
u
o
vg
sr
i
u
sr
i
ex

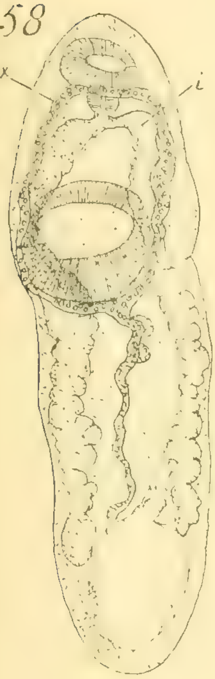
155

o
vg
vg

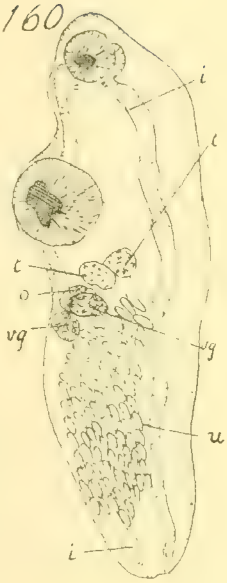
157



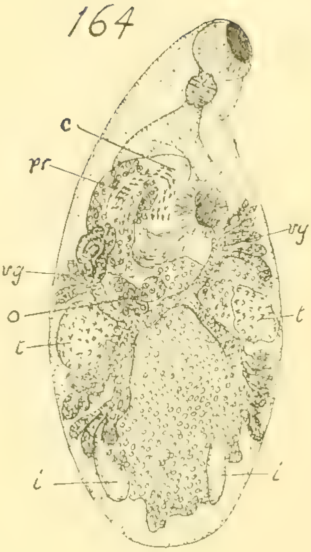
158



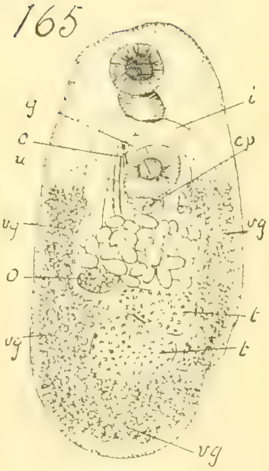
160


i
i
t
o
vg
vg
u
i

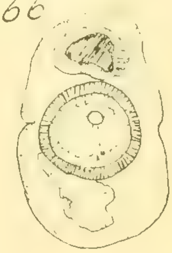
164


c
pr
vg
vg
o
t
t
i
i

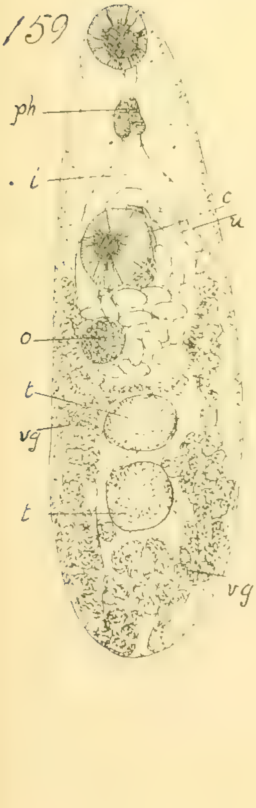
165


y
c
u
i
cp
vg
vg
o
t
vg
t
vg

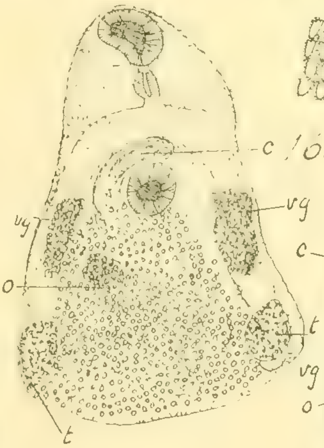
166



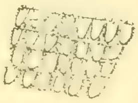
159


ph
i
c
u
o
t
vg
t
vg

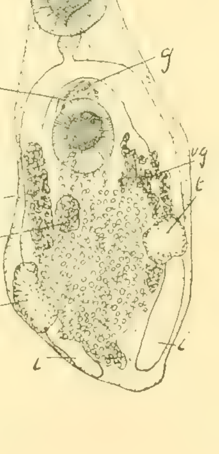
161



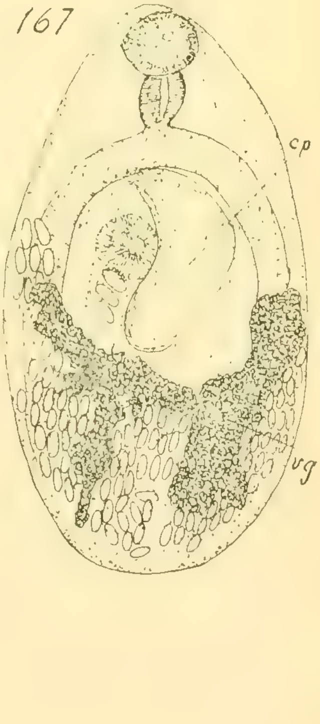
163



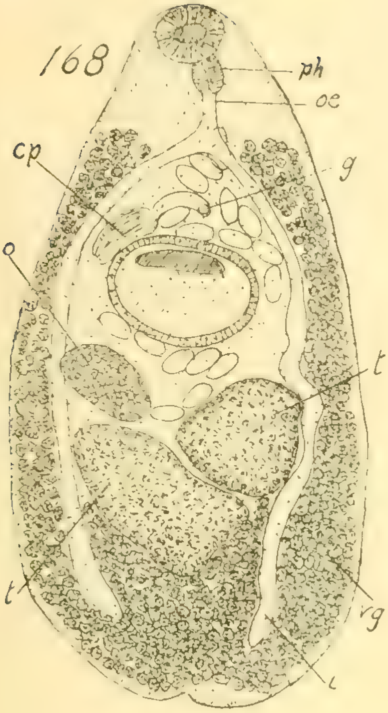
162


g
c
vg
t
vg
o
t
i
i

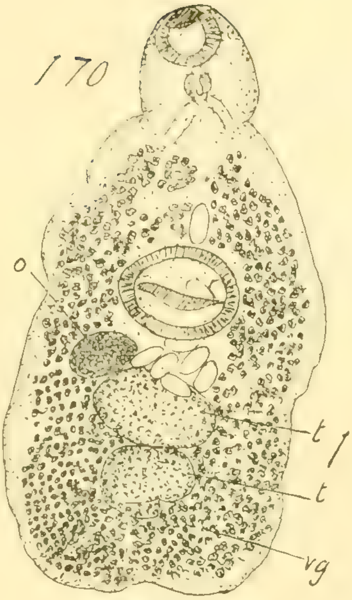
167



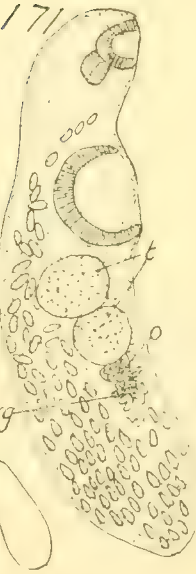
168


ph
oe
cp
g
o
t
t
vg
i

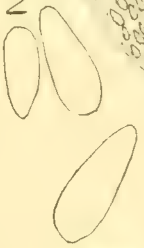
170



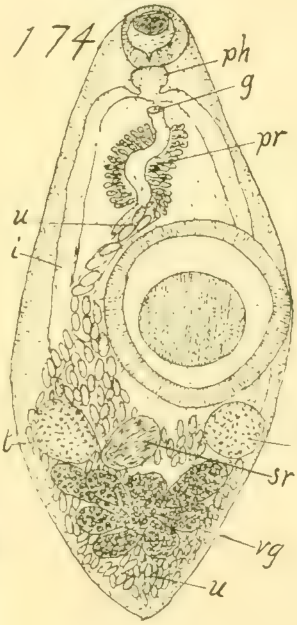
171



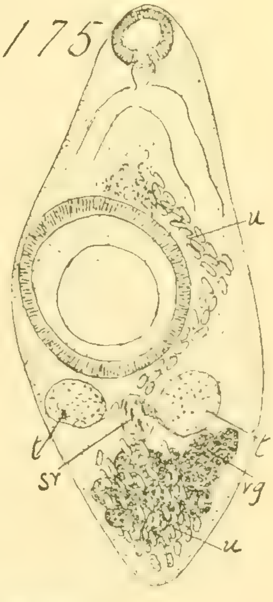
172



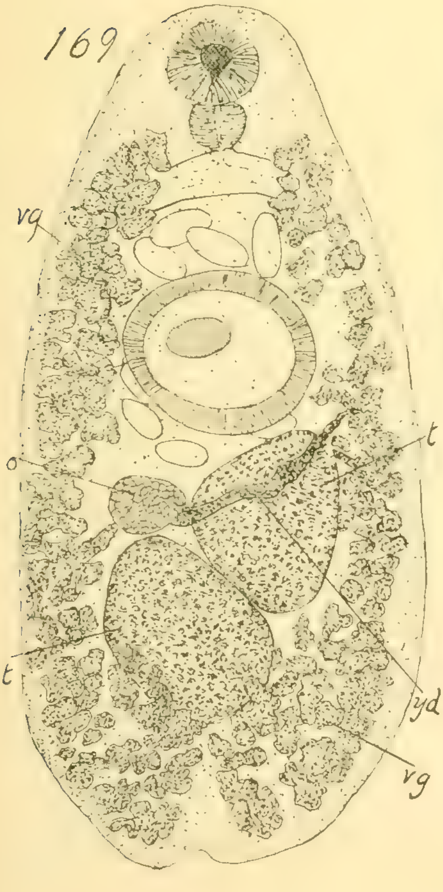
174


ph
g
pr
u
i
t
sr
vg
u

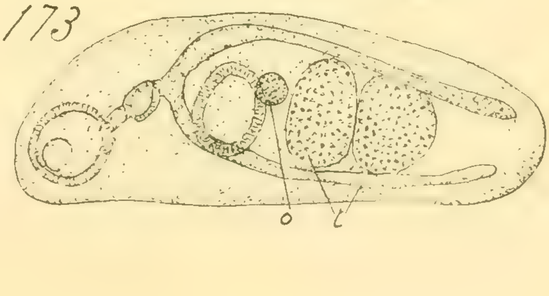
175



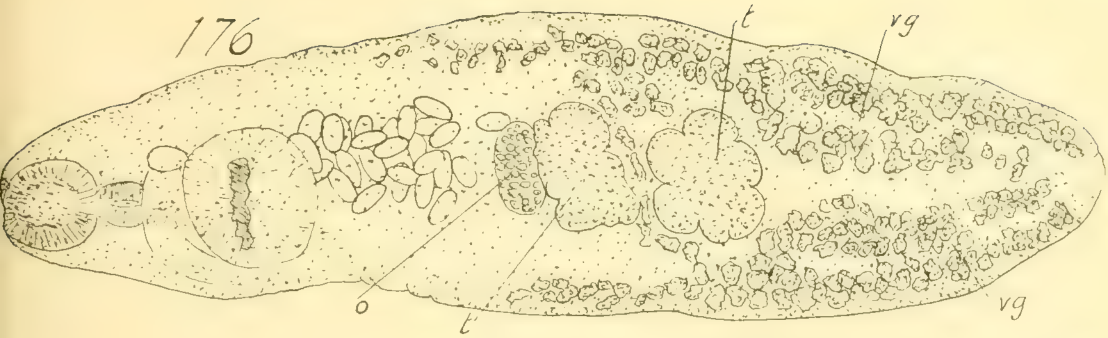
169



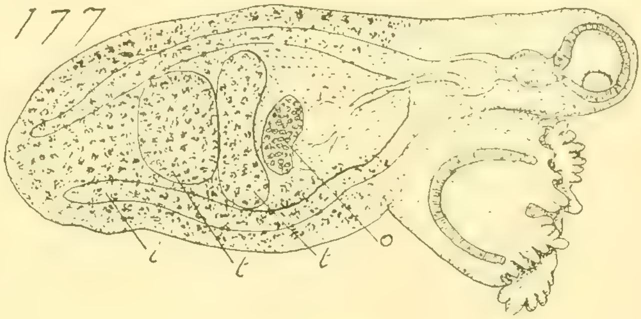
173



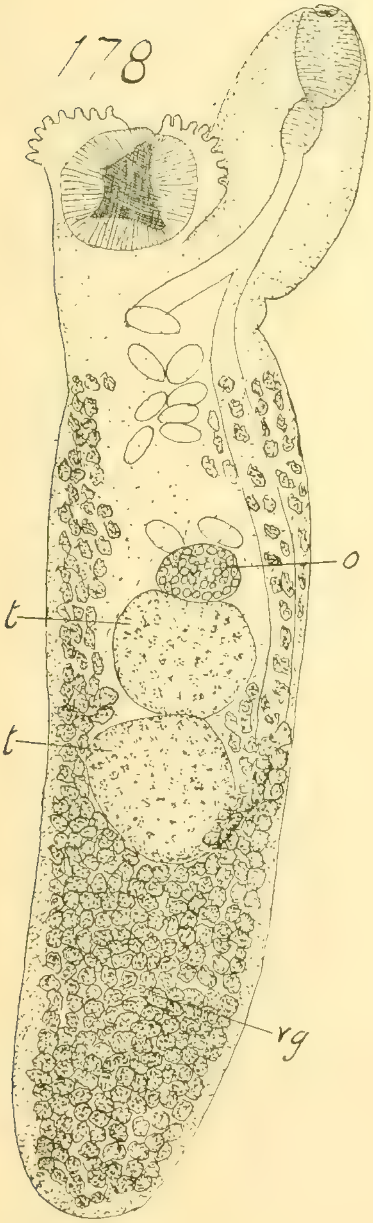
176



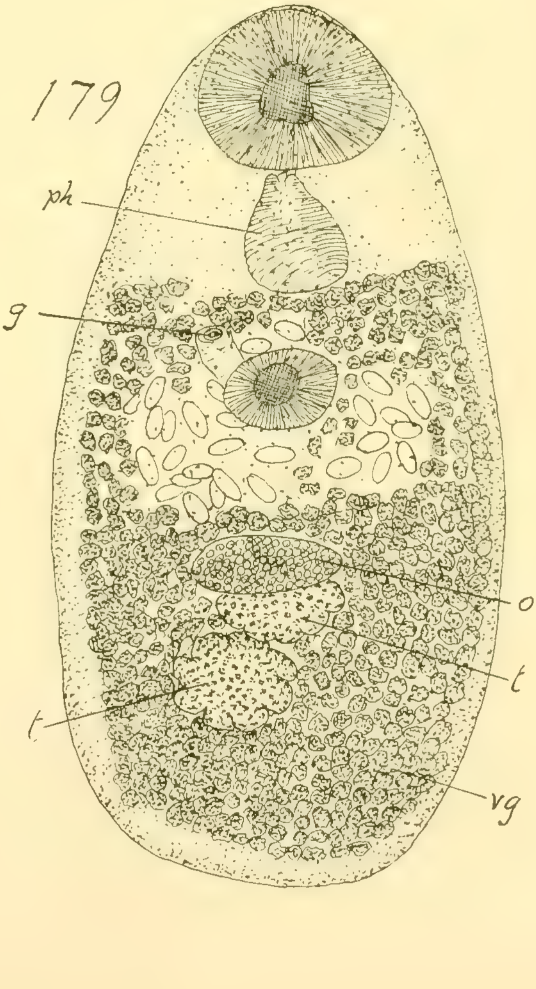
177



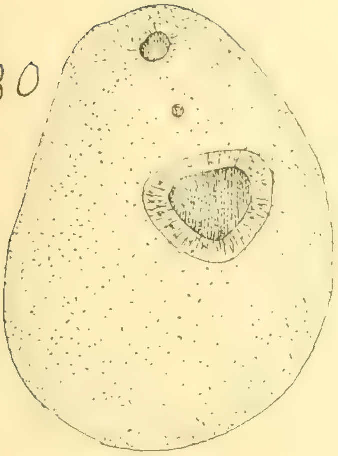
178



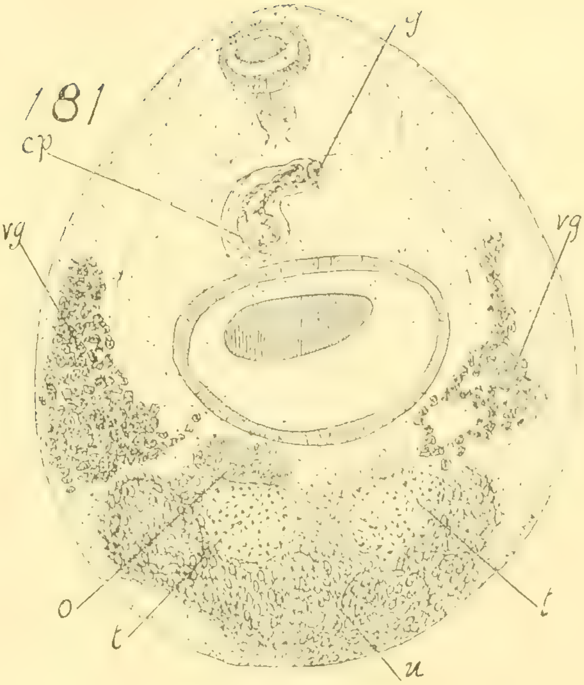
179



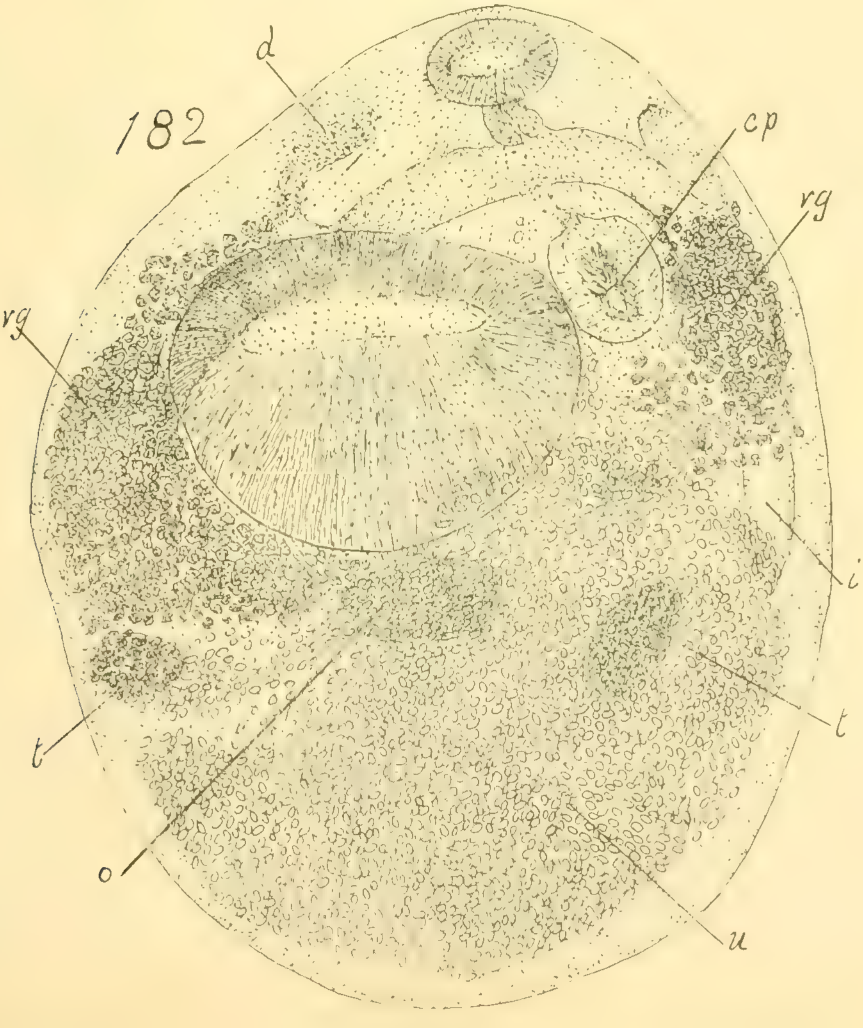
180



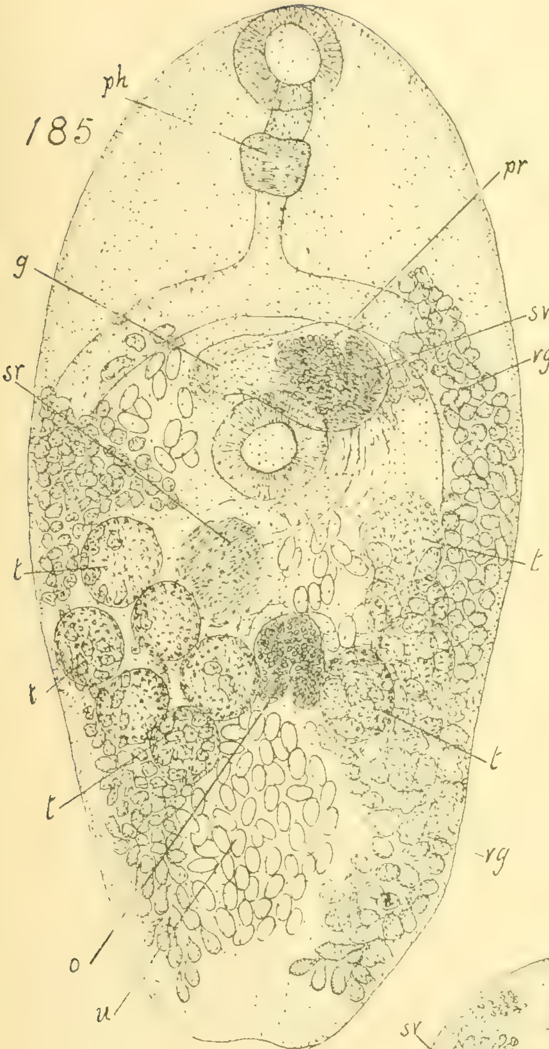
181


y
cp
vg
vg
o
t
t
u

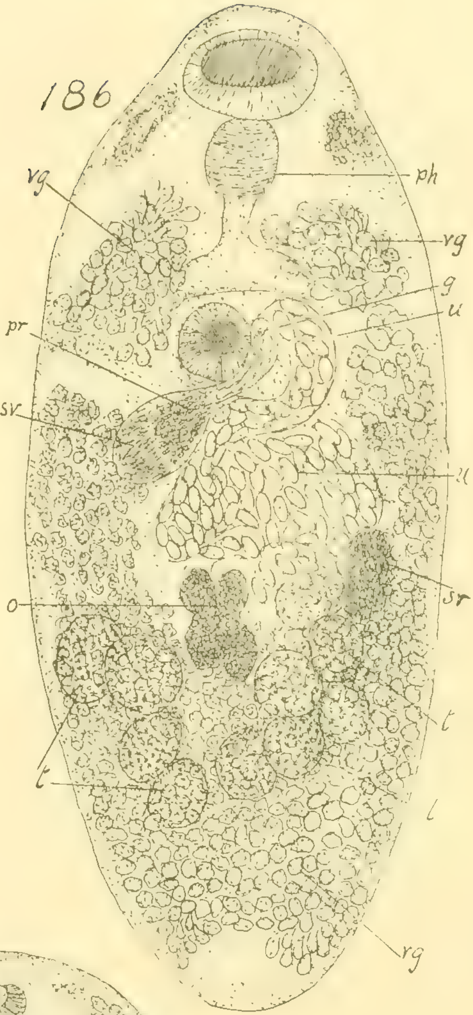
182


d
cp
vg
vg
i
t
t
o
u

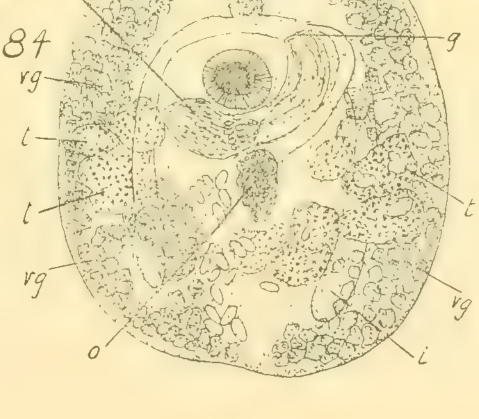
185


ph
pr
g
sv
vg
sr
t
t
t
t
t
vg
o
u

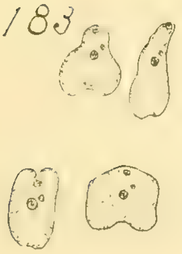
186


ph
vg
vg
g
u
pr
sv
u
sr
o
t
t
l
vg

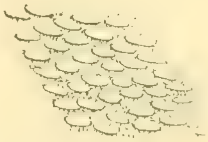
184


sv
g
vg
l
t
t
vg
vg
o
i

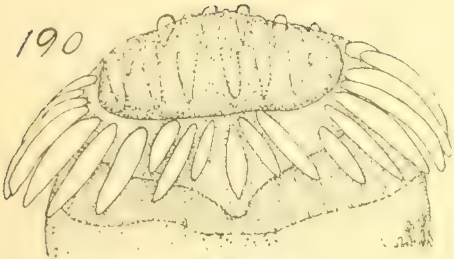
183



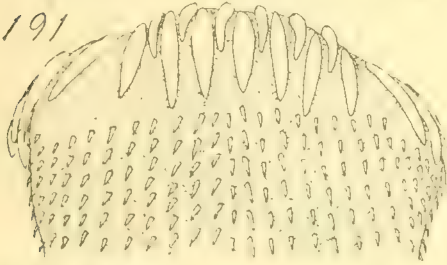
187



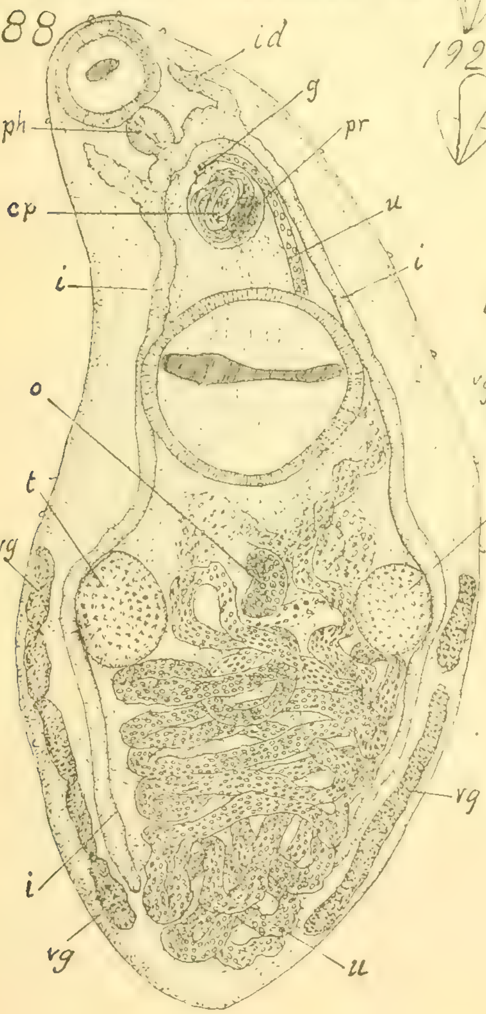
190



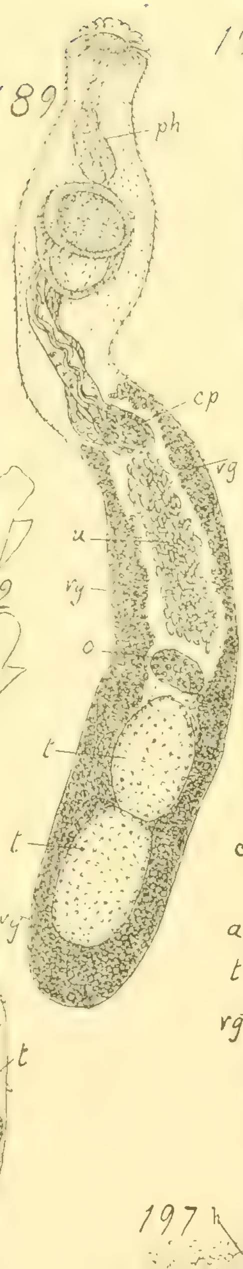
191



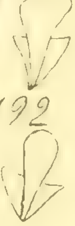
188


id
g
ph
pr
cp
u
i
i
o
t
t
vg
vg
i
vg
u

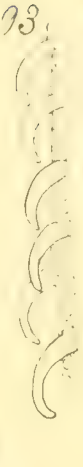
189


ph
cp
vg
u
vg
o
t
t
vg

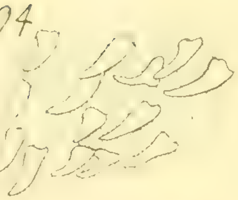
192



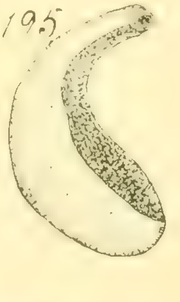
193



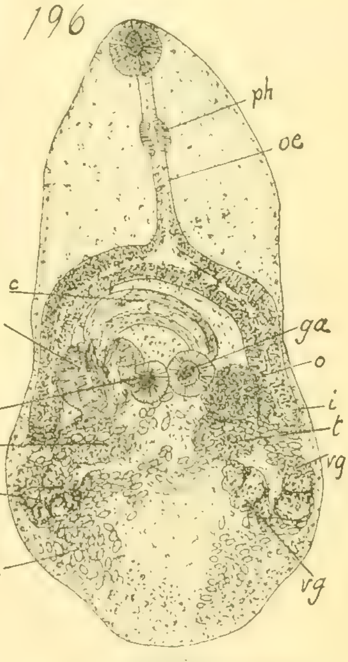
194



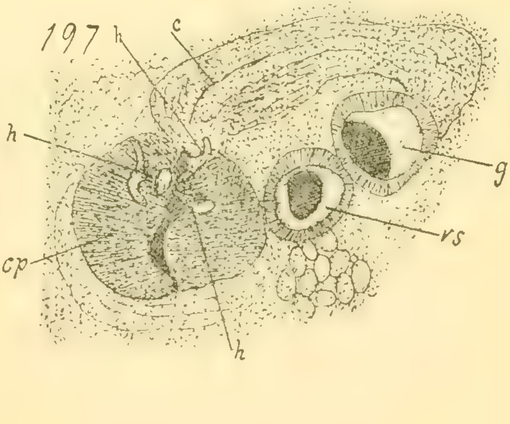
195



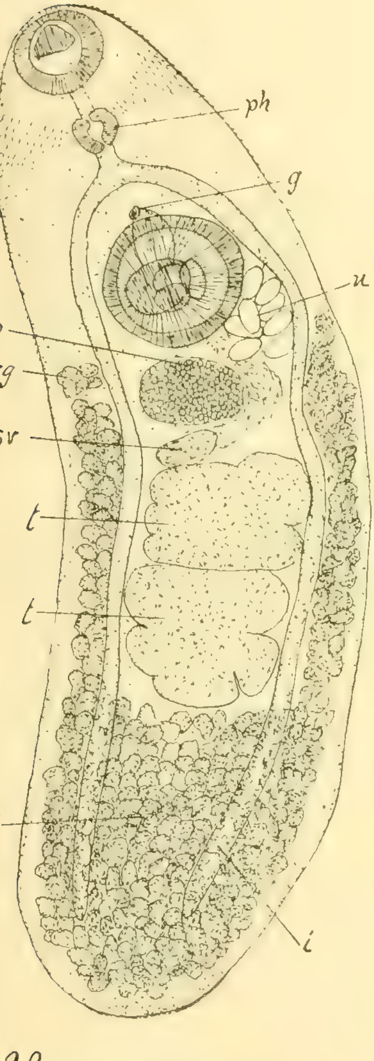
196


ph
oe
c
cp
ga
o
ac
i
t
t
vg
rg
vg
u
vg

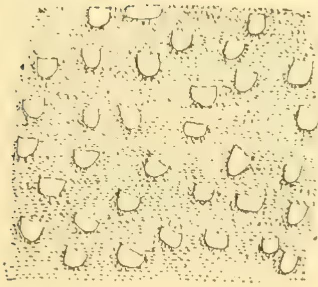
197



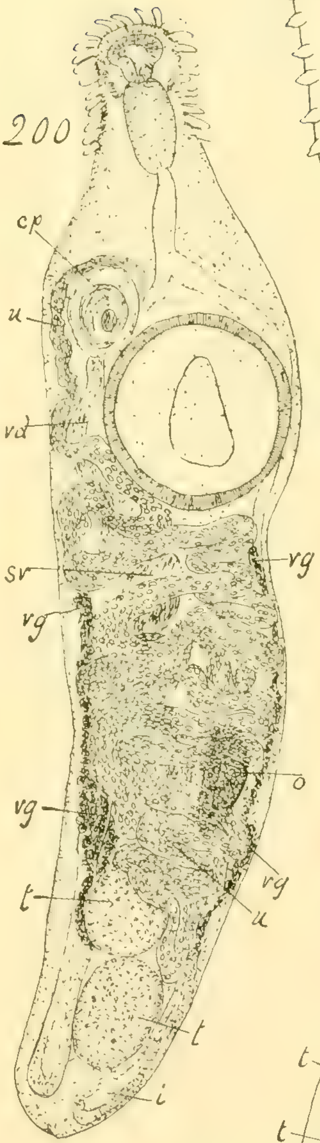
198


ph
g
u
o
vg
sv
t
t
vg
i

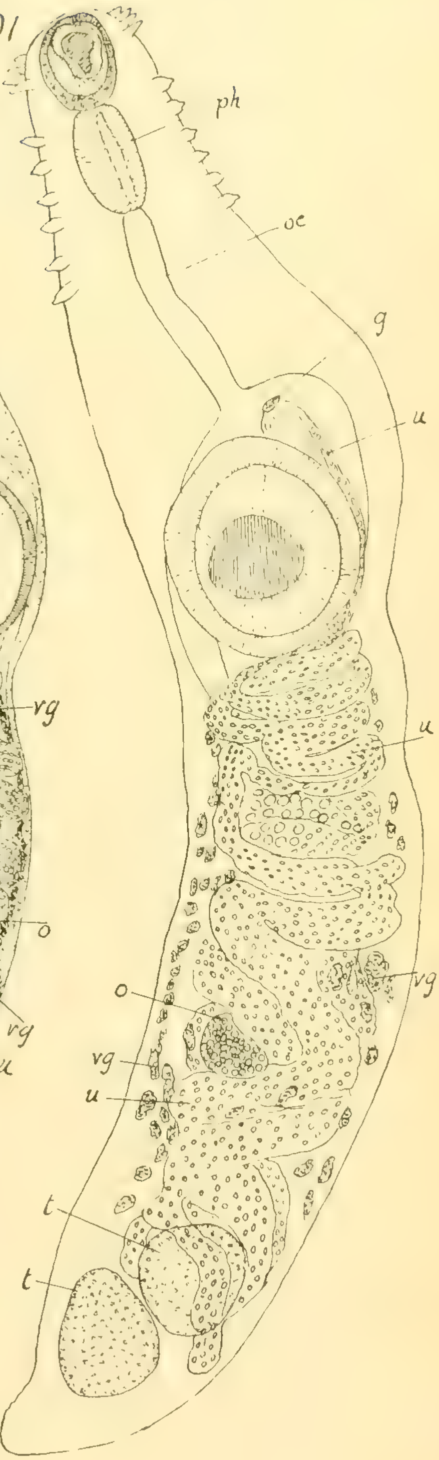
199



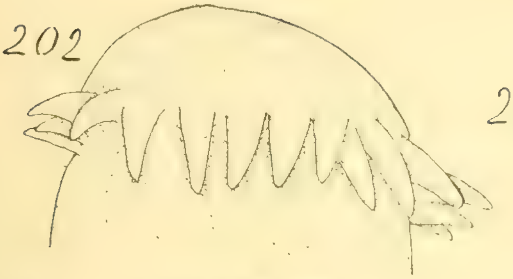
200


cp
u
vd
sv
vg
vg
vg
o
vg
u
t
t
i

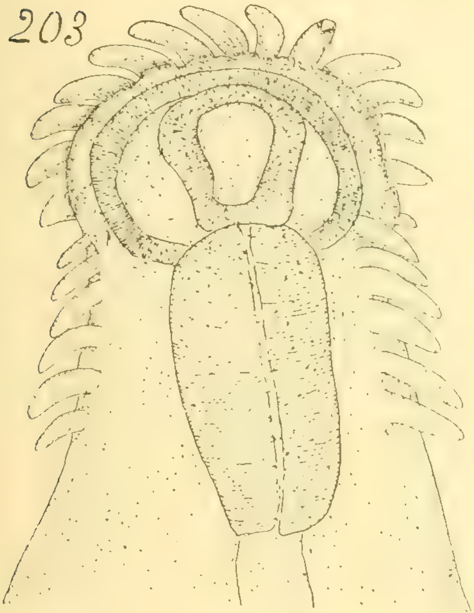
201


ph
oc
g
u
u
vg
o
vg
u
t
t

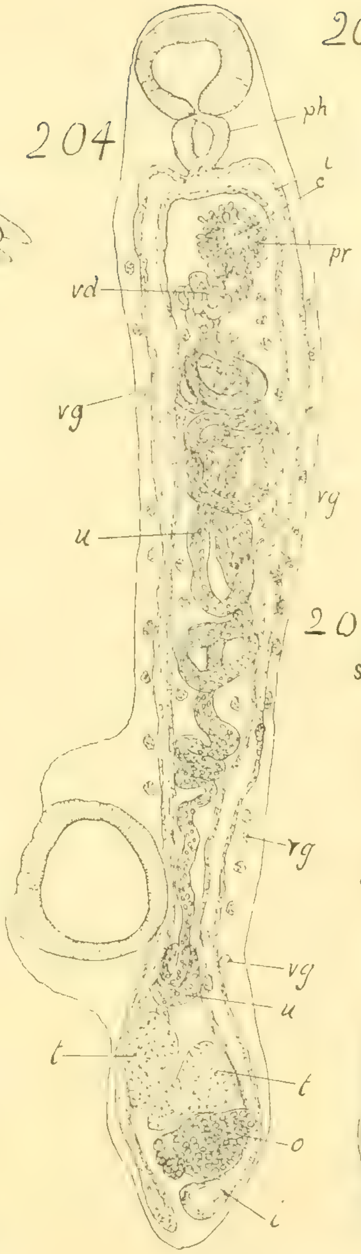
202



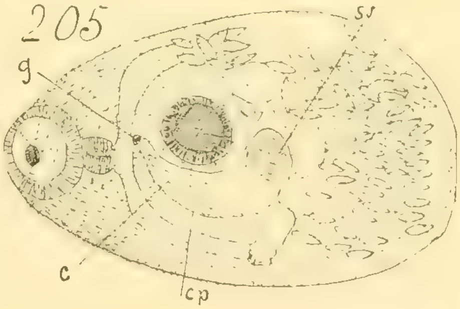
203



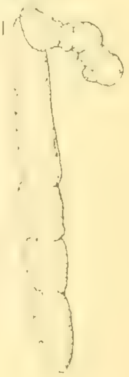
204


ph
c'
pr
vd
vg
vg
u
vg
vg
u
t
t
o
i

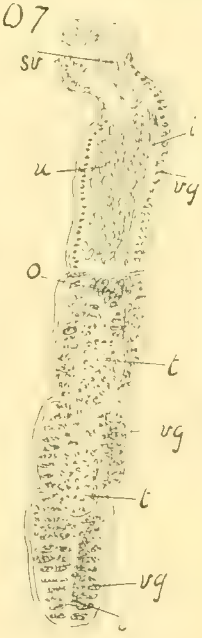
205



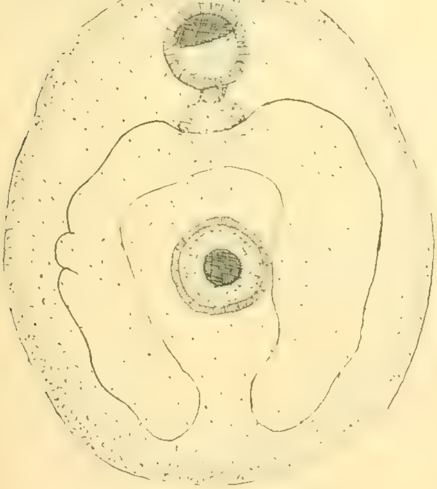
206



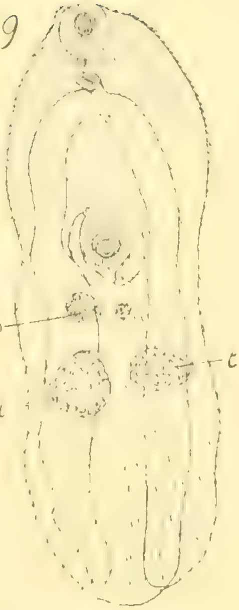
207


sv
i
u
vg
o
t
vg
t
vg
i

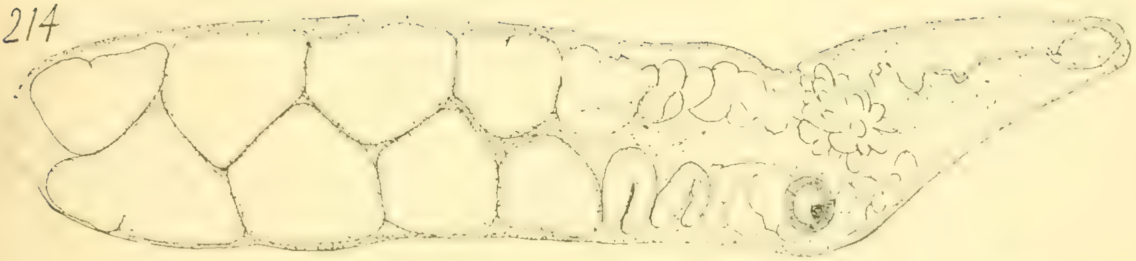
208



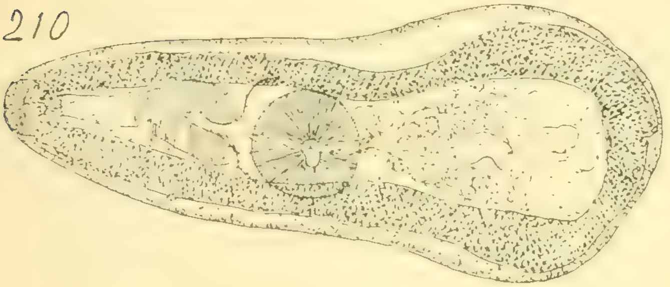
209



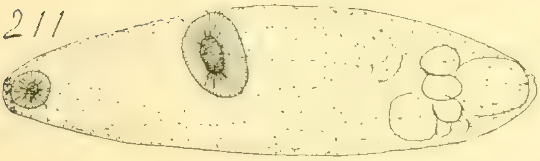
214



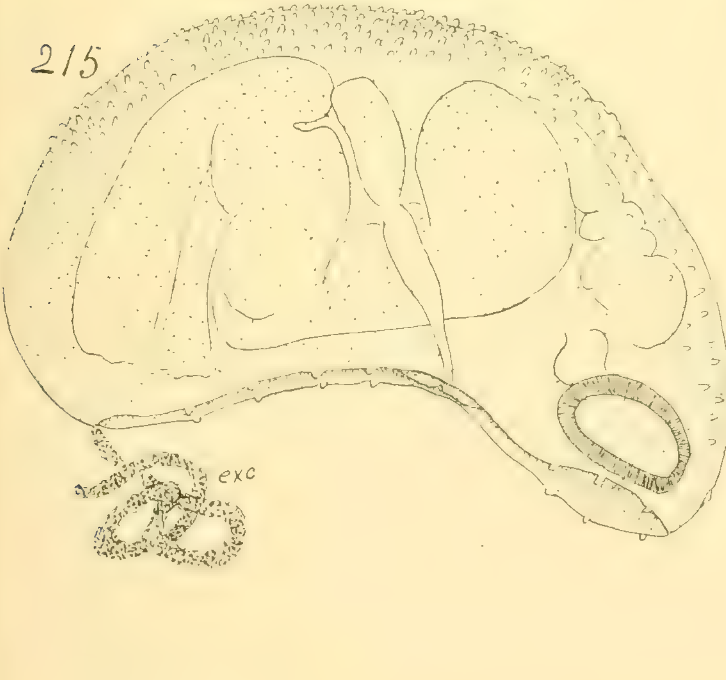
210



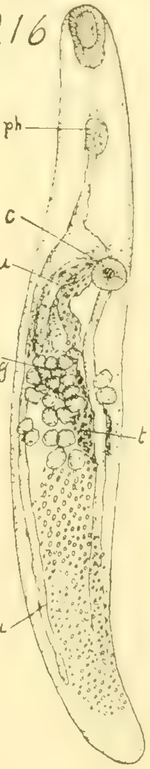
211



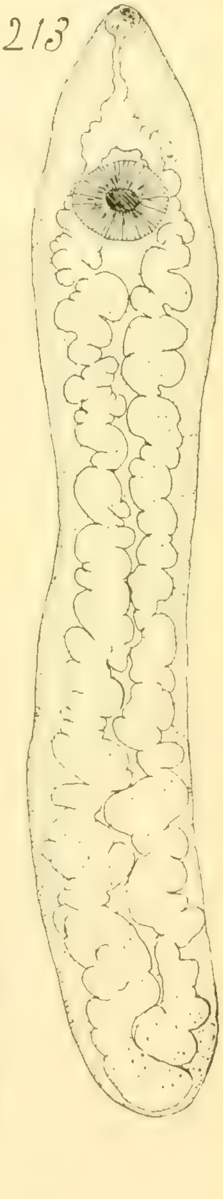
215



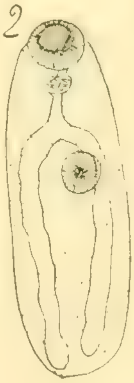
216



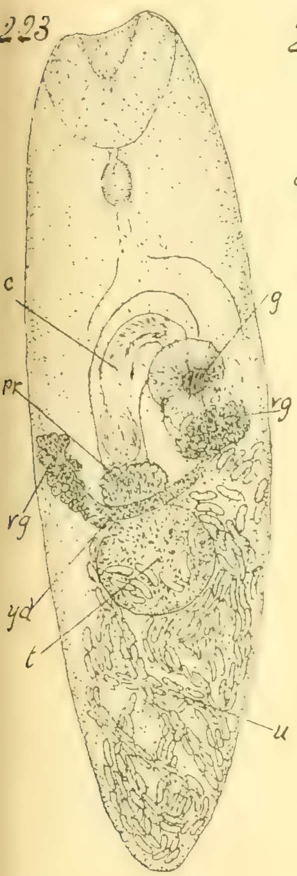
213



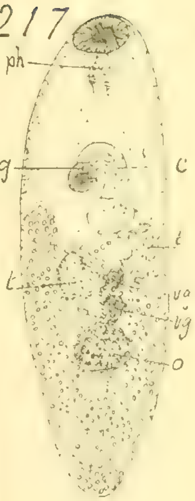
212



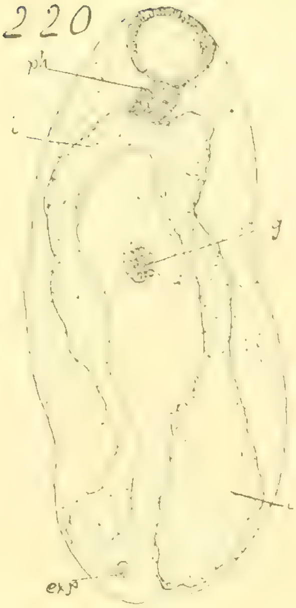
223


c
vg
pr
vg
vg
yd
t
u

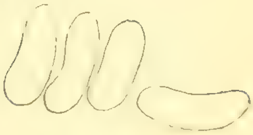
217


ph
g
c
t
t
va
vg
o

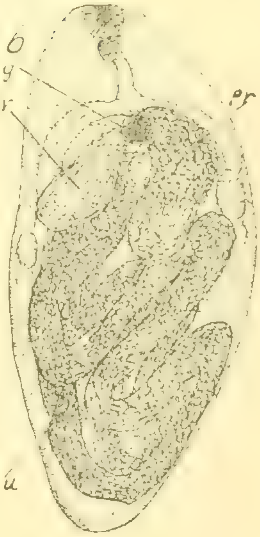
220



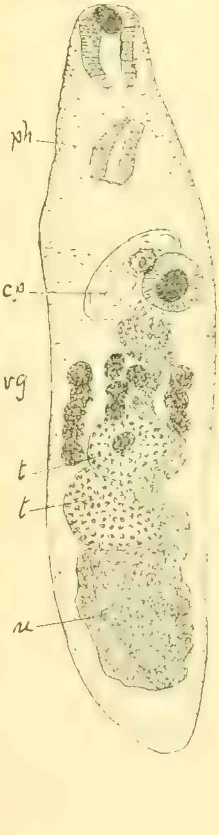
225



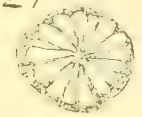
226



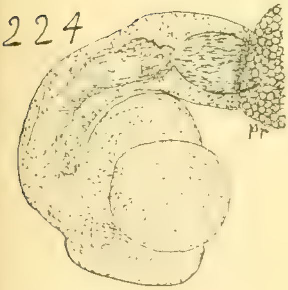
218



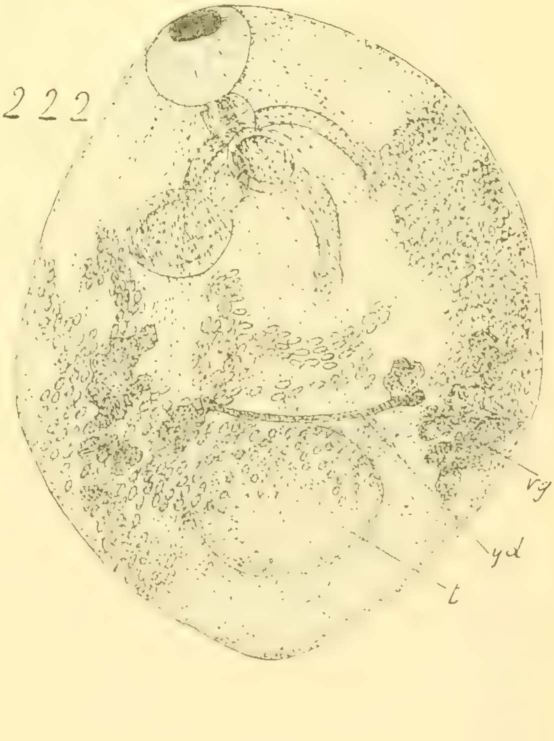
221



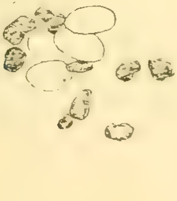
224



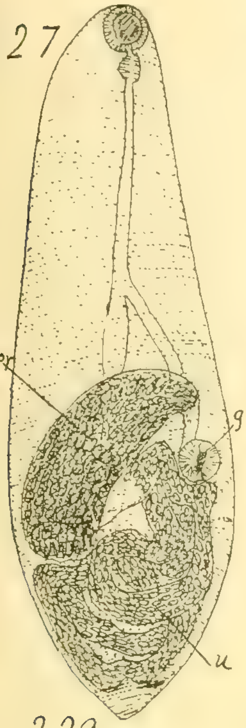
222



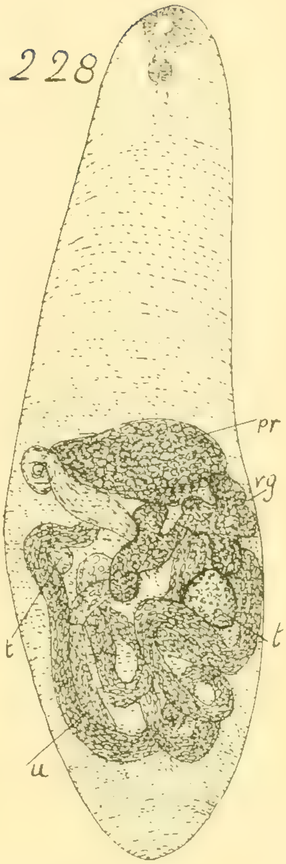
219



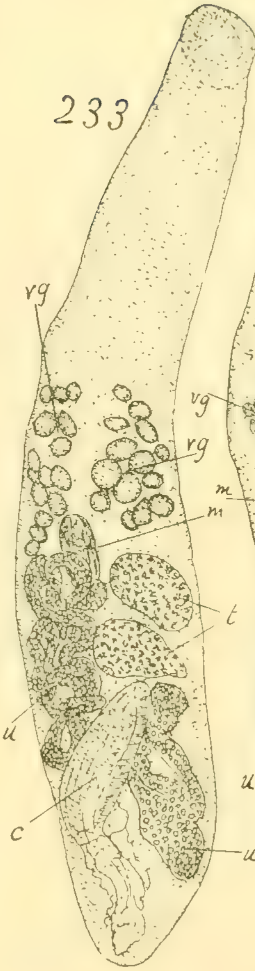
227



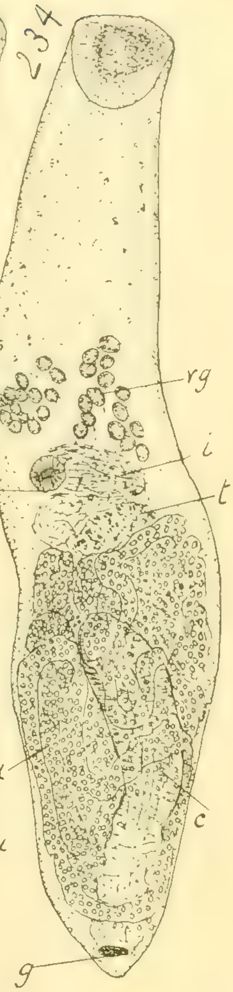
228



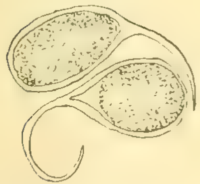
233


vg
rg
m
t
t
u
c
u

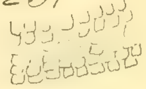
234


vg
rg
i
m
t
u
c
g

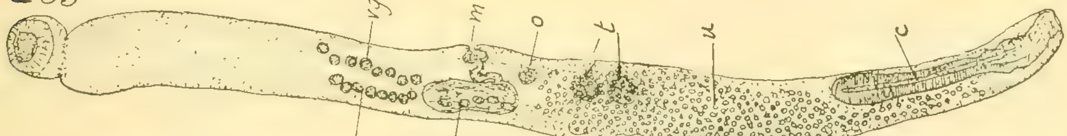
229



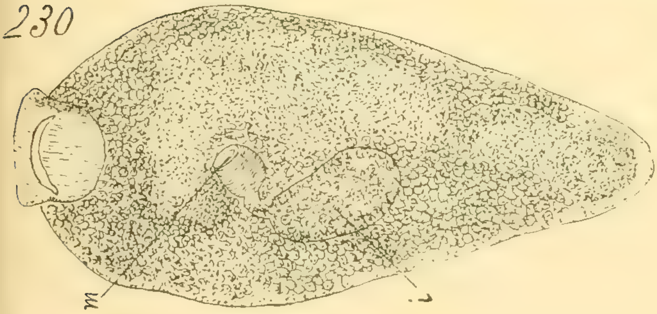
231



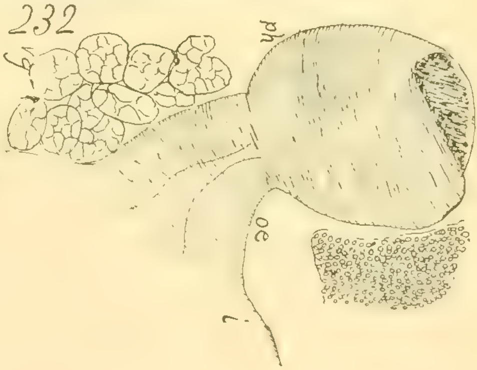
235


vg
m
o
t
u
c
vg
i

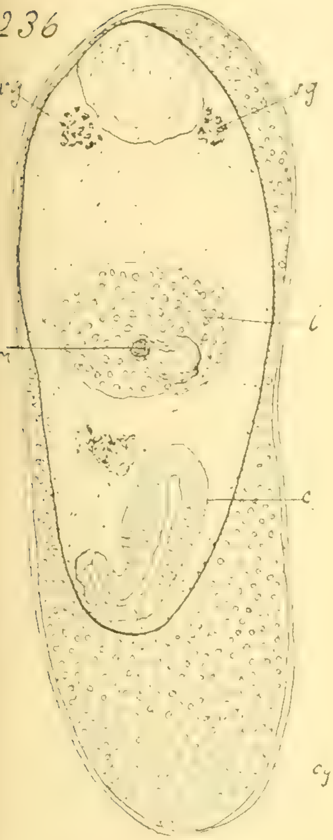
230



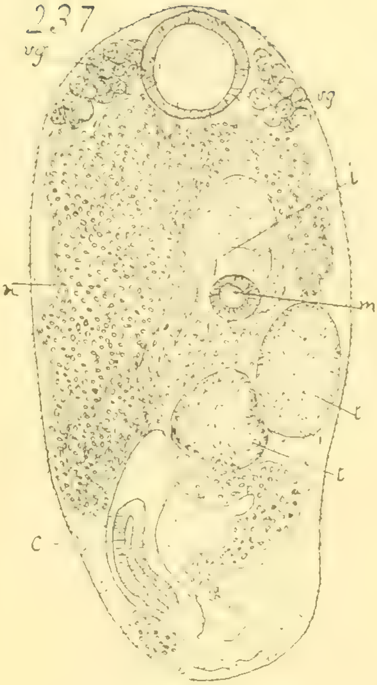
232



236

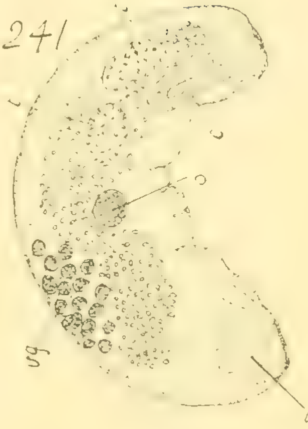


237

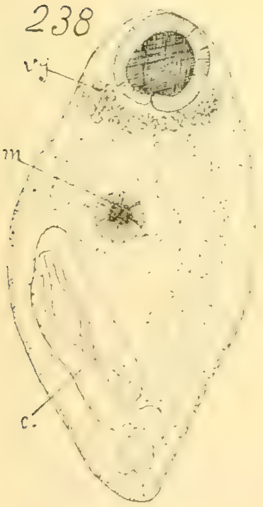

vg
vg
i
n
m
t
t
c

242

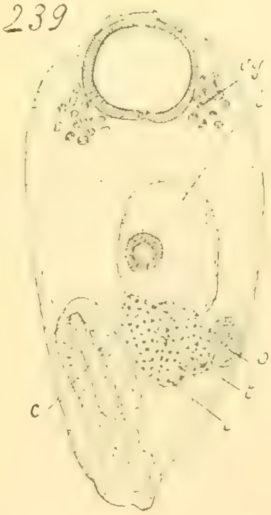
241



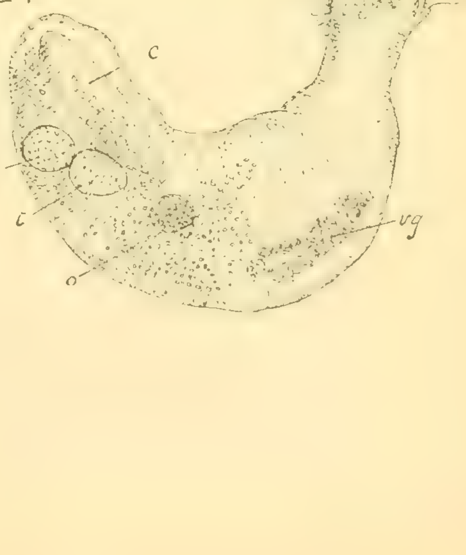
238



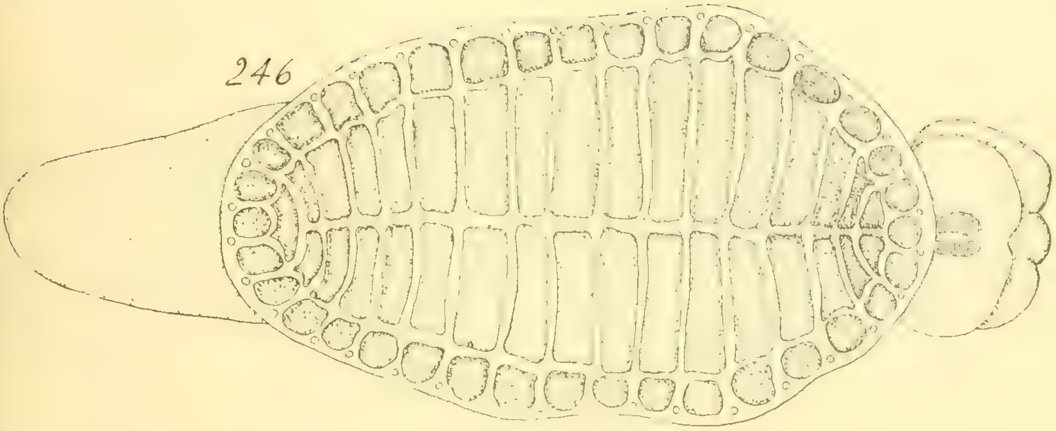
239



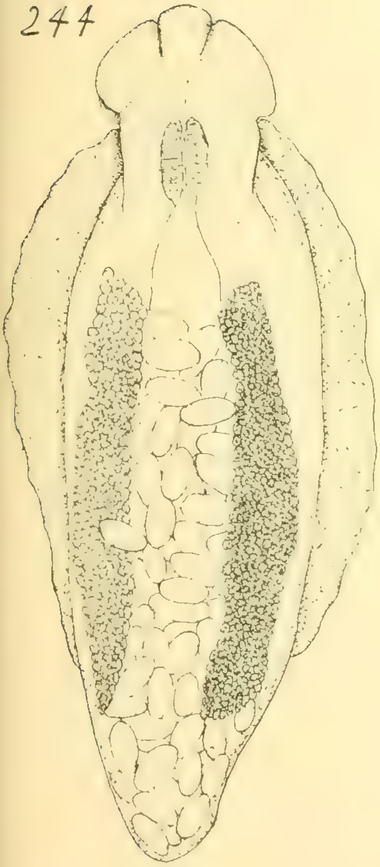
240



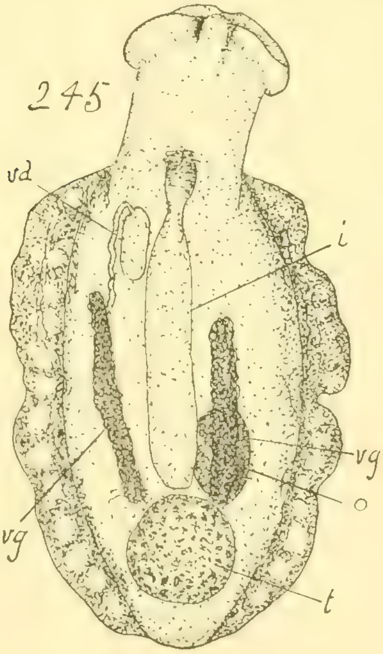
246



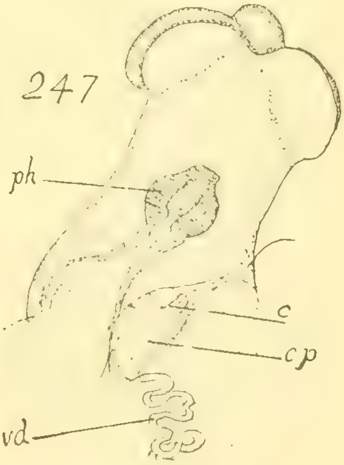
244



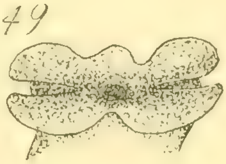
245



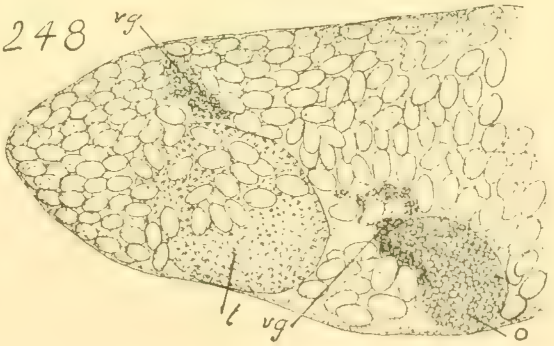
247



249



248



243

# PHYSIOLOGICAL STUDIES OF THE CHINOOK SALMON.

By CHARLES WILSON GREENE,
*Professor of Physiology, University of Missouri.*

I. Relation of the Blood Pressure to the Functional Activity.
II. A Study of the Blood and Serous Liquids by the Freezing-Point Method.

# PHYSIOLOGICAL STUDIES OF THE CHINOOK SALMON.

By CHARLES WILSON GREENE,
*Professor of Physiology, University of Missouri.*

## I. RELATION OF THE BLOOD PRESSURE TO THE FUNCTIONAL ACTIVITY.

### INTRODUCTORY.

The salmon is an anadromous fish. Its natural spawning beds are in the cold waters of the mountain streams. When the eggs are hatched and the young are able to swim, they proceed down the streams and out into the open ocean, where they feed and grow for a period of two to four years. On the approach of maturity they reenter the mouths of the rivers and make the long journey back to the spawning grounds in the mountain waters, a distance sometimes of hundreds of miles. The mature salmon as they approach the mouths of the rivers are strong and vigorous and in the very prime of condition. They have been feeding voraciously on the abundant ocean fauna and their tissues are loaded with the supply of fats and oils and other constituents which make the flesh so much sought after because of its delicious flavor and nutritious excellence.

The fact which presents so peculiar and interesting a problem, or series of problems, in fact, to the physiologist is this: The salmon takes no food after it leaves the ocean and enters fresh water.[a] The journey, it may be of hundreds of miles, is made against the swift currents, rapids, and waterfalls of the mountain streams. It matters not how long the distance nor how great the exertion that is required, all the energy must be supplied from the store of material accumulated while the fish is feeding in the ocean, material present in its body when it enters the fresh-water stream.

A prolonged fast is always of especial physiological interest. The winter sleep or hibernation of the bats, dormice, and the bears, while it is a period of fasting, is also a period of inactivity. All the vital processes are reduced to a minimum and little energy is liberated. In the salmon, on the contrary, the fasting period is the period of the greatest activity of the fish's life. The changes and reactions within the body of an animal that is giving off daily a large amount of energy, and at the same time is taking in no food to renew its vitality, present peculiar physiological phenomena. Nature herself performs the experiment of inanition in the salmon and it remains for science to unravel the details. The main question is how long and through

[a] This statement is borne out by the researches of the Bureau of Fisheries, and investigations by Miescher-Ruesch and Noel Paton on the Atlantic salmon in Europe show the same to be true of that species also.

what stages this one-sided process can advance before disintegration reaches the point at which the organized life of the individual animal must come to an end.

The numerous investigations of the U. S. Bureau of Fisheries into the natural history of the salmon—especially the migration, feeding, and spawning habits—have firmly established the facts upon which the general statements made above are based. Of the numerous workers we may especially mention the recent investigations of Mr. Cloudsley Rutter, late naturalist of the Bureau's steamer *Albatross*, who was one of the best informed men on all scientific questions that pertain to the Pacific salmon. It is to his energy and skilled insight that we are indebted for the more accurate details of the conditions under which the young make the journey from the headwaters of the rivers to the sea, also for details as to the progress of the adults to the spawning grounds, as well as for saving improvements in the methods of propagation. Mr. Rutter was at the time of his death in the midst of an exhaustive study of the embryology of the salmon.

In the solution of the problem of the changes that occur in the salmon during the run to the spawning beds, there are three general courses open, in addition to the natural-history methods of observation. One is a study of the anatomy, by which may be followed the structural changes in the salmon after it reenters the rivers. Little has been done with this method except upon the alimentary canal. A second course is through the methods of physiological chemistry. These have been applied particularly by Miescher-Ruesch in Germany, and Paton and his coworkers in Scotland. The latter especially have published some instructive and interesting studies of the chemical changes in the tissues and organs of the Atlantic salmon (*Salmo salar*). No work has been published presenting the results of a chemical study of the salmon of our west coast, though the opportunities for observation are far more numerous and the natural setting of the problem is infinitely superior to that for the study of the Atlantic salmon either on the continent of Europe or in Scotland. The European species of salmon which spawns in the rivers of Scotland (*Salmo salar*), like our American steelhead (*Salmo gairdneri*), for example, returns to the sea for another period of feeding, thus spawning more than one season. *Oncorhynchus tschawytscha*, unlike the species of *Salmo*, does not return to the sea, but spawns once and dies, as was first conclusively proved by the investigations carried on by Doctor Evermann in Idaho in 1895 and 1896.[a] It therefore presents a peculiarly favorable opportunity for the chemical study of starvation.

The third and last line of observation seeks to trace the changes in the functional activity of the salmon by the methods of experimental physiology. These methods have never been applied to the study of this species—have been applied, indeed, in only a limited number of studies on fishes of any kind. The present investigation had its origin in the belief that good and fruitful results would be yielded by such an experimental study. Under the auspices of the U. S. Bureau of Fisheries, field work was begun during the summer of 1901. Only a small portion of the total results of the physiological investigations in progress will be reported in the following pages.

---

[a] Bull. U. S. Fish Comm. for 1896, pp. 151–202, and 1897, pp. 15–84.

## METHODS.

The size of *Oncorhynchus tschawytscha*, individuals of which often weigh as much as 40 and 50 pounds, makes this a fish difficult to handle, especially since it succumbs rather quickly to artificial conditions. To take a salmon out of the water in which it lives and to keep it alive under conditions which will permit of physiological measurements is indeed about as difficult as putting a mammal under the water for such a purpose, and for much the same reasons. I have been able, however, to keep salmon alive under fairly normal conditions for as much as twenty minutes—in one case, forty-two minutes. The procedure was as follows: A salmon holder was made of a broad board supplied at one end with a grooved block, which was fitted over the nose. A similar block for the back was also used for the smaller fishes. A narrow strip of sail canvas was tacked to one edge of the board from a point opposite the shoulder-girdle to some distance back toward the tail. The head end of the holder was cut out in such a way as to allow free movement of the operculum in respiration. The salmon was placed on its side on this board, quickly wrapped in the canvas, and tied to the board by stout twine bands around the nose, the shoulder-girdle, and at intervals along the body and around the tail. The gills were aerated by a stream of water from a garden hose which siphoned water from the hatchery flume, the surface of which was about 5 feet above the operating table. The hose was inserted into the mouth and the water was allowed to flow freely out over the gills and escape on the tables and floor. Especial care was taken to have both opercles free and to direct the stream of water so that it irrigated the gills freely on both sides. The lower jaw was left free to make its respiratory movements, though these movements, of course, did not affect the artificial respiration. Blood-pressure measurements and respiratory counts were the tests made upon the salmon under these conditions.

Blood-pressure measurements were desired both of the ventral and dorsal aortæ. The difficulties in the way of measuring the pressure in the ventral aorta proved exceptionally great. The pericardial cavity extends forward and includes the conus arteriosus and the origin of the short ventral aorta. The aorta almost immediately makes a sharp turn upward toward the base of the branchial apparatus, where the afferent branchial arteries have their origin. These branchial arteries pass at once to the gillarches and it is impossible to isolate any one of them without injuring the delicate gill structure. This difficulty, together with the great coagulability of the blood, was sufficient to invalidate all the efforts to lead off the blood pressure from these vessels. The ventral aorta itself, though deep-seated in these large fishes, is more easily exposed, and after considerable practice I was able to make the necessary dissection accurately and quickly. The pectoral arch which covers the pericardial region is cartilaginous in the salmon. In exposing the ventral aorta it was necessary to cut away the greater part of the muscles of the gular region, together with the anterior portion of the pectoral arch down to the wall of the pericardium, and to slit open the extreme anterior ventral portion of the pericardium. A slight loss of blood attends this operation, but all delicate vessels are quickly and effectively stopped by rapid blood-clotting. It is evident that one can not insert a cannula into the ventral aorta in the usual way—i. e., by ligation. The vessel is too easily torn to permit the use or insertion of the form of cannula such as Fick's, and the blood clots would quickly stop it were it inserted. Successful pressures were finally secured with a short-necked, wide-bulb, T-shaped washout cannula of the form in common use in physiological laboratories and figured in Stirling's Hand-book, page 306. This cannula, filled with saturated magnesium sulphate under the proper pressure to prevent the too great loss of blood into its bulb, gave tracings unobstructed by clots for as much as ten minutes at a time, and clots could be easily removed by taking the cannula from the artery, washing it out, and replacing it. The cannula was inserted through a small puncture or slit cut in the artery with a slender pointed scalpel and was held in place not by the usual ligatures but by the elasticity of the tissue around the constricted neck of the cannula. The end of the cannula extended freely into the blood stream within the artery but was not large enough to offer any serious obstruction to the flow of the blood stream past its point of insertion. The greatest care was taken to adjust the whole apparatus with reference to the position of the fish at the beginning of the experiment so that the cannula should not be drawn out or the artery torn, either of which accidents was almost sure to end the experiment through the too great loss of blood.

Measurements of the blood pressure of the dorsal aorta were made by cutting off the tail and quickly inserting the cannula into the open end of this vessel, and plugging the accompanying veins when necessary, i. e., when they were not completely compressed by the cannula in the aorta. A little bleeding takes place around the cut skin, but a true measurement of the pressure and its variations is obtained for a period of two or three minutes and even longer.

The blood pressure in all of the experiments reported in this paper was measured by means of a Ludwig's mercury manometer, and the pressures are measured to the maximal pressures of the heart beats.

## BLOOD PRESSURE IN SALMON FROM THE SEA.

A vigorous effort was made during the summers of 1901 and 1902 to secure measurements of blood pressure from salmon taken directly from the sea. The fishing grounds at Monterey Bay, the point visited, are so far out that it is difficult to bring the fish to the shore in good condition. July 26, 1901, a single live male, 92 centimeters in length, was brought into the laboratory in poor condition, having lost some blood from a gaff wound and being considerably asphyxiated by the trip in from the fishing banks. The blood pressure measured in the ventral aorta was found to be 49 millimeters of mercury. This result can not be taken as normal, since it is vitiated both by loss of blood and by insufficient aeration of the gills during the experiment. It is of interest chiefly as the first attempt to make the difficult blood-pressure measurement on the salmon.

## BLOOD PRESSURE IN SALMON FROM TIDE WATER.

Black Diamond, California, at the head of Suisun Bay, just where the Sacramento and San Joaquin rivers enter the bay, was visited in the first two weeks in August, 1902. Two live salmon, caught in nets about 3 miles distant, were brought in a small float to the wharf of the Sacramento River Packers' Association, to whom we are indebted for quarters as well as for many special favors facilitating our investigations.

As in the case of the marine salmon, it was found impossible to transport these fish without considerable asphyxiation, and they did not revive as well as could be wished. While the pressures given in Table I, below, are strong, still they must be considered somewhat below the normal for the fish in its native waters. The heart beat is obviously far below the normal, a fact which is due to the failure of the ventricle to follow each contraction of the auricle.

TABLE I.—*Blood pressure from the ventral aorta of salmon taken from Suisun Bay at the mouth of the Sacramento River.*

| Date. | No. | Sex. | Length in millimeters. | Blood pressure in the ventral aorta in millimeters of mercury. | Heart rate per minute. |
|---|---|---|---|---|---|
| 1902. | | | | | |
| July 10 | 197 | | 756 | 78 | 15 |
| July 10 | 198 | Female | 859 | 63 | 25 |

## BLOOD PRESSURE IN SALMON FROM THE SPAWNING BEDS.

Blood-pressure experiments were performed on some forty different salmon taken from the McCloud River at Baird, Cal.[a] Twenty-one of these experiments were made in the summer of 1901 and the remaining nineteen in 1902. The majority of the fish used were young males or females that had been artificially spawned. A few were old exhausted specimens, males and females that had come down the river from the spawning beds above. Two or three were prime, large, unripe males and females. The great intrinsic value for propagation purposes of these prime fish at the hatchery deters one from using more than are absolutely necessary for experimental purposes. Figures 1 and 2 give typical ventral aortic blood-pressure tracings. Table II represents the total set of blood-pressure measurements. The maximal blood pressure, the heart rate, and the respiratory rates in all the blood-pressure experiments are brought together in the table following for convenience in reference.

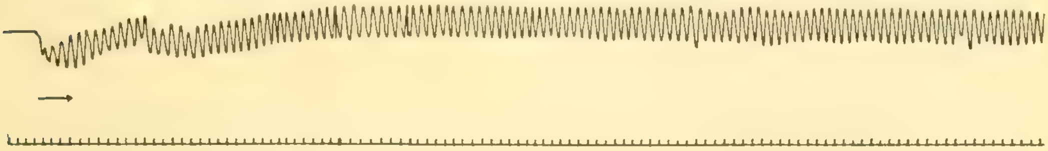


FIG. 1.—Experiment Aug. 20, 1902. Salmon, No. 207, female; length, 823 millimeters. This tracing gives a normal blood pressure from the ventral aorta. Maximal pressure, 75 millimeters of mercury; heart rate, 68 per minute; pulse pressure, 16 millimeters of mercury. In this and the following figures the tracings were recorded by means of a Ludwig's mercury manometer. The time is in seconds and the time line represents the zero pressure. All figures are reduced one-half.

---

[a] The United States fish hatchery at Baird furnishes an ideal spot for the study of the salmon on the spawning beds. An abundance of live specimens can be obtained at the very door of the hatchery, and the station is provided with the necessary equipment for handling the fish. I wish here to thank especially the superintendent, Mr. G. H. Lambson, and the accommodating hatchery force for numerous courtesies during the progress of the work.

TABLE II.—*The blood pressure and heart rate, together with the respiratory rate, of salmon from the spawning beds.*

[Experiments performed at Baird, Cal.]

| Date. | No. | Sex. | Length in millimeters. | Ventral aorta. | | Dorsal aorta. | | Respiratory rate per minute. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Blood pressure in millimeters of mercury. | Heart rate per minute. | Blood pressure in millimeters of mercury. | Heart rate per minute. | | |
| 1901. | | | | | | | | | |
| Aug. 8 | 7 | Male ..... | 520 | 60 | 45 | .......... | .......... | .......... | Beginning pressure 45, rate 24. |
| Aug. 8 | 9 | Male ..... | 540 | 62 | 72 | .......... | .......... | 75 | |
| Aug. 10 | 10 | Male ..... | .......... | 40 | 80 | .......... | .......... | 96 | Poor, irregular. |
| Aug. 12 | 14 | Male ..... | 530 | .......... | .......... | 58 | 28 | 90 | |
| Aug. 13 | 15 | Male ..... | 530 | .......... | .......... | 39 | (?) | .......... | Rate can not be determined. |
| Aug. 14 | 16 | Male ..... | 440 | 33 | 34 | .......... | .......... | 72 | Poor. |
| Aug. 14 | 17 | Male ..... | 1,020 | 44 | 21 | .......... | .......... | 70 | Old male off retaining rack; died in a few minutes. |
| Aug. 14 | 18 | Male ..... | 530 | .......... | .......... | 68 | 72 | .......... | |
| Aug. 15 | 19 | Male ..... | .......... | 38 | 40 | .......... | .......... | .......... | Poor. |
| Aug. 15 | 20 | Male ..... | 520 | .......... | .......... | 30.4 | (?) | .......... | |
| Aug. 16 | 22 | Female... | 850 | 86 | 60 | .......... | .......... | 64 | Spawned naturally. |
| Aug. 17 | 23 | Male ..... | 540 | 47 | 86 | .......... | .......... | .......... | |
| Aug. 17 | 24 | Female... | 900 | 80 | 58 | .......... | .......... | 78 | Spawned artificially. |
| Aug. 28 | 48 | Male ..... | 650 | 64 | 52 | .......... | .......... | 75 | After 6 minutes' pressure 66, rate 51. |
| Aug. 28 | 52 | Female... | 850 | 100 | 57 | .......... | .......... | 63 | Spawned artificially. |
| Aug. 28 | 53 | Female... | 730 | 57 | 69 | .......... | .......... | .......... | Do. |
| Aug. 28 | 54 | Female... | 890 | 120 | 60 | .......... | .......... | 63 | Do. |
| Aug. 28 | 55 | Female... | 900 | 67 | 63 | .......... | .......... | 40 | Spawned artificially; experiment continued for 40 minutes. |
| Aug. 29 | 59 | Female... | 1,160 | 70 | 63 | .......... | .......... | 62 | Spawned naturally; after 28 minutes' pressure 67, rate 56; experiment continued 42 minutes. |
| Sept. 1 | 60 | Female... | 870 | 70 | 52 | .......... | .......... | 65 | Spawned artificially; after 23 minutes' pressure 70, rate 50. |
| Aug. 31 | 61 | Male ..... | 920 | 108 | 34 | .......... | .......... | .......... | Rate and pressure very irregular. |
| 1902. | | | | | | | | | |
| Aug. 18 | 201 | .......... | .......... | 59 | 66 | .......... | .......... | 102 | |
| Aug. 18 | 202 | .......... | .......... | 28 | 66 | .......... | .......... | 75 | Poor. |
| Aug. 18 | 203 | Male ..... | 428 | 69 | 76 | .......... | .......... | .......... | |
| Aug. 19 | 204 | Male ..... | 459 | 45 | 54 | .......... | .......... | 72 | |
| Aug. 19 | 206 | Male ..... | 935 | 94 | 66 | .......... | .......... | 50 | Old male off retaining rack. |
| Aug. 20 | 207 | Female... | 823 | 75 | 68 | .......... | .......... | 54 | Spawned artificially. |
| Aug. 21 | 208 | Male ..... | 413 | 75 | 60 | .......... | .......... | 79 | |
| Aug. 22 | 209 | Male ..... | 918 | 99 | 44 | .......... | .......... | 60 | |
| Aug. 23 | 210 | Female... | 672 | 66 | 64 | .......... | .......... | 60 | Unripe; after 10 minutes' pressure 64, rate 72. |
| Aug. 23 | 212 | Female... | 777 | 66 | 76 | .......... | .......... | 60 | Spawned artificially. |
| Aug. 25 | 213 | Male ..... | 752 | 94 | 56 | .......... | .......... | 71 | Just ripening. |
| Aug. 26 | 214 | Female... | 829 | 50 | 48 | .......... | .......... | 61 | |
| Aug. 26 | 215 | Female... | 866 | 73 | 66 | .......... | .......... | 52 | |
| Aug. 26 | 216 | Male ..... | 510 | .......... | .......... | 51 | (?) | 78 | Pressure fell rapidly. |
| Aug. 27 | 217 | .......... | 590 | 85 | 56 | .......... | .......... | 0 | Cocainized, no respiratory movements. |
| Aug. 27 | 218 | Male ..... | 600 | 43 | 68 | 44 | 60 | 60 | Dorsal pressure measured first. |
| Aug. 27 | 219 | Male ..... | 860 | 72 | 20 | .......... | .......... | .......... | Fresh male in fine flesh and color. |
| Aug. 28 | 220 | Male ..... | 490 | 33 | 90 | 57 | 48 | 80 | Dorsal pressure measured first. |
| Aug. 28 | 221 | Male ..... | 440 | 56 | .......... | 52 | 38 | .......... | Do. |

A comparison of the experiments in this list, which may be considered as representing the results in normal animals, is interesting in several important respects. The experiments of this class showing the blood pressure in the ventral aorta have been selected and are presented below in Table III, from which it will be seen that the mean pressure for the 26 examples is 74.6 millimeters of mercury.

TABLE III.—*Showing the blood pressure in the ventral aorta, the heart rate, and the pulse pressure of all the examples that were considered normal under the conditions of experimentation.*

| Date. | No. | Sex. | Length in millimeters. | Pressure in the ventral aorta. | Heart rate per minute. | Pulse pressure in millimeters. |
|---|---|---|---|---|---|---|
| 1901. | | | | | | |
| Aug. 8 | 7 | Male ....... | 520 | 60 | 45 | 40 |
| Aug. 9 | 9 | Male ....... | 540 | 62 | 72 | 3 |
| Aug. 16 | 22 | Female..... | 850 | 86 | 60 | 14 |
| Aug. 17 | 23 | Male ....... | 540 | 47 | 86 | 6 |
| Aug. 17 | 24 | Female..... | 900 | 80 | 58 | 12 |
| Aug. 28 | 48 | Male ....... | 650 | 64 | 52 | 18 |
| Aug. 28 | 52 | Female..... | 850 | 100 | 57 | 18 |
| Aug. 28 | 53 | Female..... | 730 | 57 | 69 | 8 |
| Aug. 28 | 54 | Female..... | 890 | 120 | 60 | 16 |
| Aug. 28 | 55 | Female..... | 900 | 67 | 63 | 16 |
| Aug. 29 | 59 | Female..... | 1,160 | 70 | 63 | 14 |
| Sept 1 | 60 | Female..... | 870 | 70 | 52 | 22 |
| Aug 31 | 61 | Male ....... | 920 | 108 | 34 | 36 |
| 1902 | | | | | | |
| Aug 18 | 201 | .............. | .......... | 59 | 66 | 6 |
| Aug 18 | 203 | Male ....... | 428 | 69 | 76 | 10 |
| Aug 19 | 204 | Male ....... | 459 | 45 | 54 | 6 |
| Aug 19 | 206 | Male ....... | 935 | 94 | 66 | 8 |
| Aug 20 | 207 | Female..... | 823 | 75 | 68 | 16 |
| Aug 21 | 208 | Male ....... | 413 | 75 | 60 | 8 |
| Aug 22 | 209 | Male ....... | 918 | 99 | 44 | 18 |
| Aug 23 | 210 | Female..... | 672 | 66 | 64 | 14 |
| Aug 24 | 212 | Female..... | 777 | 66 | 76 | 18 |
| Aug 25 | 213 | Male ....... | 752 | 94 | 56 | 20 |
| Aug 26 | 214 | Female..... | 829 | 50 | 48 | ........... |
| Aug. 26 | 215 | Female..... | 866 | 73 | 66 | 14 |
| Aug. 27 | 217 | .............. | .......... | 85 | 56 | 16 |
| Mean for 26 specimens | | | | 71.6 | 58.9 | ........... |
| Mean for 11 males | | | | 74.3 | 58.6 | ........... |
| Mean for 13 females | | | | 75.4 | 61.8 | ........... |

The highest pressure recorded in any single instance was that of a female (No. 54) 89 centimeters in length, taken Aug. 28, 1901, which had been artificially spawned a few hours before. This female was in prime condition in so far as shown by external appearances. It gave a ventral aortic pressure of 120 millimeters of mercury. A male 92 centimeters long, taken Aug. 31, 1901, gave almost as great a maximal pressure, i. e., 108 millimeters of mercury. The minimal pressures included in the above table are 45 and 47 millimeters, respectively, given by Nos. 204 and 23. No. 23, taken Aug. 17, 1901, was marked in the notes as a "prime-condition fish," yet the pressure is very low, although the heart rate is considerably above the average.

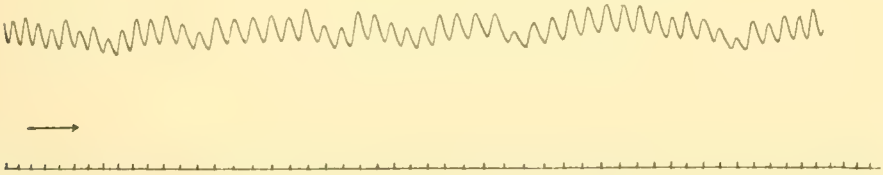


FIG 2.—Experiment Aug. 28, 1901, No. 48, male; length, 650 millimeters. Showing a type of blood pressure tracing from the ventral aorta in which the respiratory movements affect the pressure. See also fig. 3.

TABLE IV.—*Showing the range of variations in the ventral aortic blood pressure in normal salmon from the spawning beds.*

| Number of specimens. | Ventral aortic pressure, in millimeters of mercury. |
|---|---|
| 3 | 41 to 50 |
| 3 | 51 60 |
| 8 | 61 70 |
| 4 | 71 80 |
| 2 | 81 90 |
| 4 | 91 100 |
| 1 | 101 110 |
| 1 | 111 120 |
| 26 specimens | Mean, 74.6 |

It must be remembered, however, that in a series of experiments of this nature the artificial conditions tend to lower the natural or normal pressure which exists while the fish is in its natural habitat. Such events as loss of blood, inadequate respiratory arrangements, change in external pressure on the surface of the body exerted by the air as compared with that of the water, increase of body temperature in the air over that in the water out of which the specimen has just been taken, as well as the general indeterminate conditions that affect the vitality of these river salmon—all these act to minimize the observed pressures.

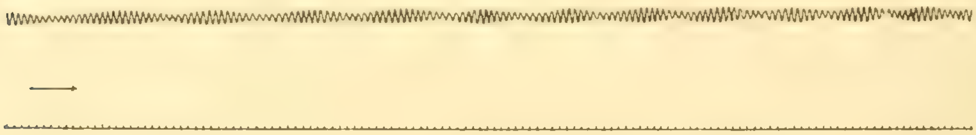
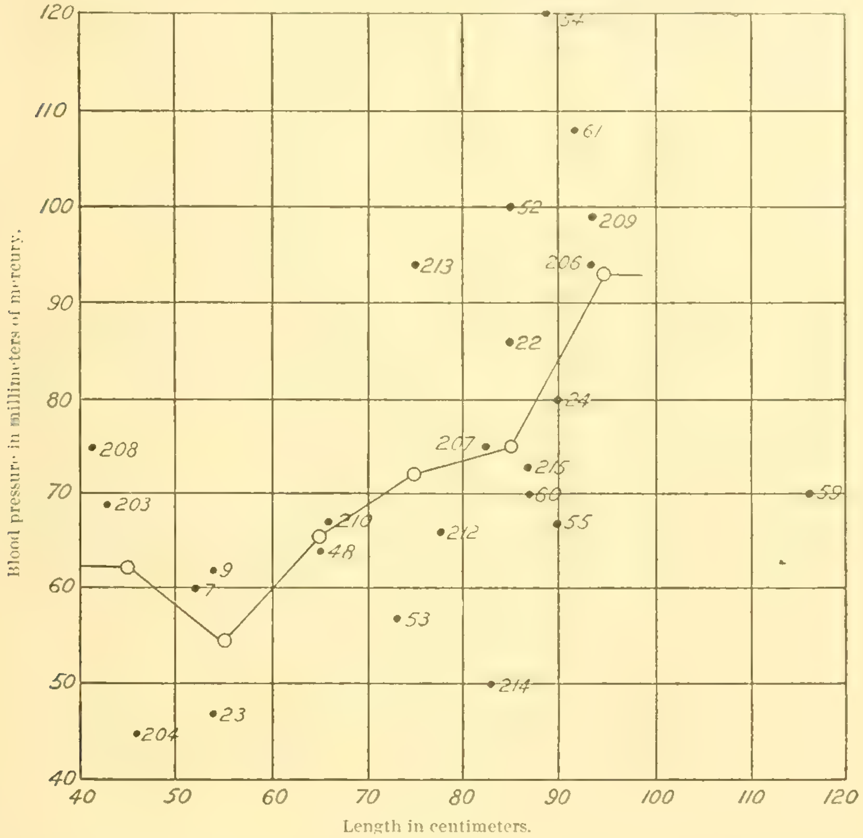


FIG. 3.—Experiment Aug 23, 1902, No. 210, female; length, 672 millimeters. Blood pressure from the ventral aorta, showing the rhythmic interference of the respiratory movements with the pulse pressure.

The 11 males used, varying from 428 to 935 millimeters in length, gave an average ventral aortic pressure of 74.3 millimeters of mercury. This is the equivalent of 101 centimeters of water. With the fishes, as with the higher animals, the larger specimens of otherwise equal physical condition may be expected to give slightly higher pressures. Indeed, a reference to Table V below will show at a glance that such is the case for the salmon. The mean or average pressure for all the specimens between 70 and 100 centimeters in length is 82.6 millimeters of mercury, the equivalent of 112.4 centimeters of water pressure. The pressure in the smaller specimens between 40 and 70 centimeters in length is only 61 millimeters of mercury or 83 centimeters of water. The relatively slight intrinsic value of the smaller fish, which are invariably males, and the greater facility in securing and manipulating them in experiments, leads to their use in larger numbers. When the mean pressure is compared in the males alone, the difference is much more striking. The 7 males between 40 and 70 centimeters in length gave an average pressure of 60 millimeters, while the 5 larger males between 70 and 100 centimeters long averaged 96 millimeters pressure. The pressure of 74.3 millimeters of mercury may, therefore, be considered somewhat lower than the average pressure of prime male salmon.

Table V.—*Showing the relation of the normal ventral aortic blood pressure to length in 24 specimens. The line is drawn through the mean or average. The figures refer to the specimen numbers.*



The mean blood pressure for the 13 females included in the table of relatively normal fish is 75.4 millimeters of mercury. These salmon vary in length from 67.2 to 116 centimeters, and the blood pressures obtained from 50 to 120 millimeters of mercury. The majority of these specimens were artificially spawned females, hence a question may be raised as to how far these represent the normal or average condition of the circulatory apparatus. The artificially spawned females that were used were allowed to recuperate for several hours or even for a day or two after the eggs were taken and before the blood pressure was measured. One would think that the artificial spawning process would leave the fish more or less completely exhausted, but this does not seem to be the case, barring the temporary asphyxia that comes from keeping the specimens out of the water for the time required to spawn them. When thrown back into the water these females become lively and vigorous in a very short time. An illustration will suffice to explain the situation. A series of four selected females from the ripe pen were artificially spawned on the morning of Aug. 28, 1901, then thrown back into a pen to recover for the experiments of blood pressure. The afternoon of the same day these females, Nos. 52, 53, 54, and 55, gave good strong pressures, as will be seen by a glance at the table below. One of them, No. 54, gave the highest blood pressure obtained during the whole series of experiments, namely, 120 millimeters of mercury, or 163 centimeters of water. These four fish to all external appearance seemed of equal vigor, and the pressures were taken under very favorable conditions, yet the results gave practically the extremes of the entire series.

TABLE VI.—*Showing blood pressure of four artificially spawned females taken under the same conditions.*

| | Millimeters of mercury. |
|---|---|
| No. 52, ventral aortic pressure | 100 |
| No. 53, ventral aortic pressure | 57 |
| No. 54, ventral aortic pressure | 120 |
| No. 55, ventral aortic pressure | 67 |

The vigor of the artificially spawned females is quite apparent. They do not succumb so quickly to the artificial aeration of the gills, and have more vitality on the experimental table than the prime conditioned fish which, presumably, have more recently arrived on the spawning grounds.

The exhausted fish which were secured off the retaining racks gave surprising blood pressures. No. 17, taken Aug. 14, 1901, was a ripe spent male, 102 centimeters long. This fish gave the ventral aortic pressure of 47 millimeters, though it quickly died on the table. A naturally spawned female, No. 59, taken Aug. 26, 1901, gave a pressure of 70 millimeters, which is almost as much as the average for all the females measured. An exhausted male taken Aug. 19, 1902, gave the stronger pressure of 94 millimeters for a short time, though the pressure was very irregular.

## DORSAL AORTIC BLOOD PRESSURE.

The blood pressure measured in the ventral aorta being led off that vessel at a point anterior to the first afferent branchial vessel should represent the maximal pressure of the entire system. In order to determine the fall in pressure as the blood flows through the gills, it is necessary to measure the pressure in some one of the systemic vessels, the nearer the dorsal aortic trunk the better. Schoenlein measured the pressure from the afferent branchial artery and from one of the abdominal arteries in the torpedo and in sharks, and found a very decided fall in the latter as compared with the pressure measured in the first afferent branchial artery. He gave the pressure in the afferent branchial artery in the torpedo as 22 to 24, in no case over 30, centimeters of water (16 to 22 millimeters mercury), while in the branch of the dorsal aorta and in one of the abdominal arteries the pressure was only 10 to 12 centimeters of water as a maximum. This great difference secured by Schoenlein must have been due to the effect of the branchial resistance, which is presumably high in the Selachii.

The dorsal aorta itself was used in my experiments on the salmon. In order to reach it, the tail of the salmon was cut off by a quick stroke and the arterial cannula inserted into the open end of the aortic trunk. The apparatus was all carefully adjusted with reference to the position of the fish before any cutting was done, and the time between the cutting of the artery and the insertion of the cannula was thus reduced to a minimum. The cannula itself usually compressed the vein in the hæmal arch enough to prevent bleeding, and the bleeding from the small cutaneous vessels, which may be considerable if left alone, was easily checked by a tight ligature thrown around the body just in front of the cut. This ligature should be laid during the preliminary preparations.

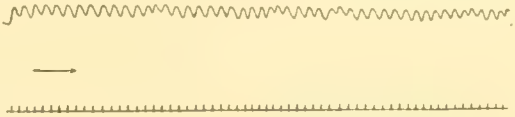


FIG. 4.—Experiment Aug. 28, 1902, No. 220, male; length, 490 millimeters. Blood pressure from the dorsal aorta. The strong pulse beat is noteworthy. Blood pressure, 57 millimeters of mercury; heart rate, 48 per minute.

The blood pressure from the dorsal aorta is quite strong in the salmon, reaching as much as 58 millimeters of mercury in the maximal pressure measured (fig. 4). The average pressure for the six examples reported in Table VII is 53.3 millimeters of mercury, with the extremes of 44 and 58. The mean heart rate of this series is 49.2 per minute, while the average noted in connection with the measurements of ventral aortic pressure is 61 (for males alone 60). This lower average heart rate suggests the inference that the resulting mean blood pressure is below the normal average. This is no doubt possible on account of the slight loss of blood attendant on the operation, a loss which, though small, is felt all the more on account of the relatively small amount of blood in the salmon.

TABLE VII.—*Blood pressure and heart rate measured from the dorsal aorta.*

| Date. | No. | Sex. | Length in millimeters. | Pressure in the dorsal aorta in millimeters of mercury. | Heart rate per minute. |
|---|---|---|---|---|---|
| 1901. | | | | | |
| Aug 12 | 14 | Male | 530 | 58 | 28 |
| Aug 14 | 18 | Male | 530 | 58 | 72 |
| 1902 | | | | | |
| Aug 26 | 216 | Male | 590 | 51 | (?) |
| Aug 27 | 218 | Male | 600 | 44 | 60 |
| Aug 28 | 220 | Male | 490 | 57 | 48 |
| Aug 28 | 221 | Male | 440 | 52 | 38 |
| Mean | | | | 53.3 | 49.2 |

The striking thing about the results of these measurements, notwithstanding the criticism offered above, is the fact that the pressure in the caudal portion of the dorsal aorta approaches so nearly that of the ventral aorta. It would seem that the resistance to the blood flow through the gills is comparatively slight, and the reduction of blood pressure correspondingly insignificant. This fact is further borne out by the presence of the dorsal aortic pulse, which is generally strong and of considerable amplitude. It would be of comparative interest if the pressure could be taken from one of the efferent branchial arteries, but in the salmon this would be extremely difficult, if not wholly impossible. The visceral branches of the aortic trunk are so much atrophied in salmon from the spawning beds that the method of measurement from these vessels, though very easy in the Selachii, is quite impracticable in the salmon.

No synchronous measurements of the pressure in the ventral and in the dorsal aortæ have been made, on account of lack of duplicate apparatus while in the field. Consecutive measurements are of little comparative value, owing to the necessary loss of blood in making the transfer of the cannula from one vessel to the other in the methods it was necessary to use. In the consecutive experiments reported it will be seen that the measurements taken second are considerably below the average, except in a single experiment, No. 221.

## THE RATE AND FORCE OF THE HEART BEAT IN THE SALMON.

The tracings of the blood pressure taken from the ventral aorta at a point so near the heart, as was the case in the experiments reported in this paper, give considerable information about the heart itself. The 26 specimens given in Table III, page 437, give an average heart rate of 58.9—in round numbers 60—contractions per minute, or 1 per second. This rate seems rather rapid for so large a fish. A glance at the series of experiments shows a wide range of rates in different specimens, the extremes being 34 and 86 per minute, respectively. There seems no close correspondence between rate of heart beat and blood pressure. The three specimens giving the highest ventral aortic pressures, Nos. 52, 54, and 61, with pressures of 100, 120, and 108 millimeters of mercury, have heart rates of 57, 60, and 34 contractions per minute, respectively. It will be noticed, however, that the pulse pressure of No. 61 is very high, a fact which accounts for the maintenance of a strong blood pressure with a low heart rate. On the other hand, No. 23, which has a heart rate of 86 per minute, has a blood pressure in the ventral aorta of only 47 millimeters, while the average pressure of fish of this size is 60 millimeters.

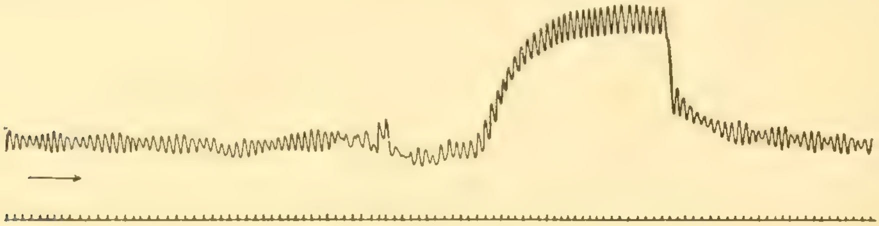


FIG. 5.—Experiment Aug. 23, 1902, No. 212, female; length, 777 millimeters. Showing the maximal blood pressure in the ventral aorta when that vessel is completely occluded. Pressure before occlusion of the aorta, 46 millimeters of mercury; after occlusion, 113 millimeters.

The pulse pressure, i. e., the increase of blood pressure accompanying each discharge of the heart into the aorta, varies exceedingly. In general the slower the rate the greater the amplitude of the pulse, though the exceptions are too numerous to conclude that the pulse pressure is an index of the rate; neither is it an index of the absolute pressure. Selected experiments indicate that there are factors to be determined which correlate the force and rate of the heart beat against the resistance to the discharge through the gills.

The possible force of the heart is indicated by the experiment of compressing the aorta, thus blocking the discharge of the blood and compelling the heart to contract to its fullest capacity. The maximal pressure is surprisingly great in these tests, as can be seen by reference to Table VIII.

TABLE VIII.—*Effects on the blood pressure and upon the heart rate produced by compressing the ventral aorta to the point of complete closure.*

| Date. | No. | Sex. | Length in millimeters. | Closure of the ventral aorta. | | | |
|---|---|---|---|---|---|---|---|
| | | | | Blood pressure in millimeters of mercury. | | Heart rate per minute. | |
| | | | | Before. | During. | Before. | During. |
| 1902. | | | | | | | |
| Aug. 18 .. | 203 | Male .......... | 428 | 1st, 54 | 126 | 63 | 60 |
| Aug. 18 .. | 203 | Male .......... | 428 | 2d, 53 | 137 | 66 | 66 |
| Aug. 19 .. | 204 | Male .......... | 459 | 40 | 78 | 58 | 58 |
| Aug. 20 .. | 207 | Female ...... | 823 | 50 | 100 | 66 | 60 |
| Aug. 23 .. | 212 | Female ...... | 777 | 46 | 113 | 70 | 70 |
| Aug. 25 .. | 213 | Male .......... | 752 | 67 | 172 | 64 | 68 |

In one case, No. 213, a pressure of 67 millimeters before compression of the aorta was increased to 172 millimeters during compression. During this high pressure the heart rate and the pulse pressure remain practically the same as before compression, the rate increasing only 4 beats per minute. These tests reveal a latent power of the heart quite enough to double the blood pressure, and, therefore, to double the efficiency of the circulation if there is any coordinating mechanism by which the salmon may call into activity this latent or potential heart energy, a fact which remains to be seen.

## NERVOUS REGULATION OF THE HEART.

My experiments have proved that the heart responds to vagus stimulation and to reflexes. It was noticed over and over again that during the dissections made in the process of experiments the heart was often very irregular. An example is given in figure 6, where cutting away the margin of the opercle in the process of exposing the vagus nerves led to well-marked cardiac inhibitions, with fall of blood pressure. These inhibitions can be brought about reflexly by stimulating various parts of the skin. Direct stimulation of the vagus nerve with rapidly interrupted induction currents produced marked slowing of the heart rate with fall of blood pressure during the continuance of the stimulation. If the currents used were strong enough the slowing of the heart passed over into complete inhibition. The heart escaped from inhibition with single strong contractions, these contractions coming at long

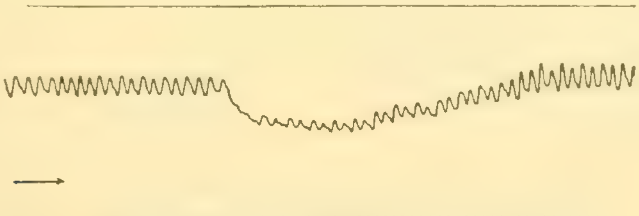


FIG. 6.—Experiment Aug. 22, 1902, No. 209, male; length, 918 millimeters. Showing the fall in ventral aortic pressure and the irregular heart rate following cutaneous stimulation.

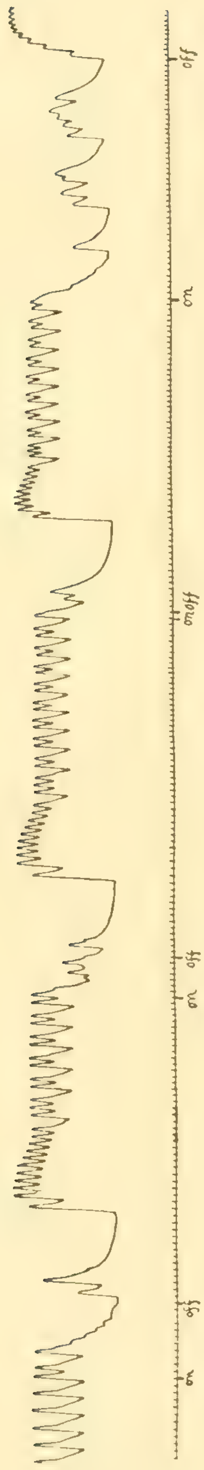


FIG. 7. Experiment Aug. 29, 1901, No. 9, female, length, 1 160 millimeters. Showing the effect on the blood pressure in the ventral aorta and on the heart rate following stimulation of the vagus nerve. The stimulation in each instance was applied between the words "on" and "off." The inhibitory effects last a considerable time after the stimulation is removed.

intervals as the heart filled with blood, a phenomenon I have noticed in quite a number of different species of fishes. Figure 7 shows the effects of a series of short stimulations of the vagus in a large specimen, 116 centimeters in length.

No accelerator influences were noticed in any of the experiments of this series, though I ought to say that the work on the nervous coordination of the circulatory system has not been completed.

There is a well-defined respiratory influence on the circulation in the salmon. This finds expression in the tracings in a rhythmic variation in the pulse pressure and to a slight extent in the total blood pressure in the ventral aorta. The respiratory movements consist of alternate opening and closing of the inferior maxilla and the opercles. The total result of the movement is a rhythmical variation in the pressure of the pericardial sac exerted through that part of the wall formed by the branchial apparatus. This movement has been described in other fishes (*Leuciscus dobula*) as exerting an aspiratory function which materially assists in the return of blood to the heart.[a] Be this as it may, it seems clear from my experiments that the respiratory movements exert an influence which increases the pulse pressure when it falls together in time with the heart beat and decreases the pulse pressure when in opposite phase. The respiratory rate is so nearly synchronous with the heart rate that the resulting curve, illustrated by figure 3 (p. 438), often presents a very marked similarity to the vibrations of a reed or tuning fork showing beats. No respiratory influence was noticed on the blood pressure in the dorsal aorta.

## SUMMARY.

In a review of these experiments on the circulatory apparatus, one can not but note the general vigor of the heart and circulation in the salmon. The main facts may be summarized as follows:

1. The heart rate is relatively high, the force of the beats as measured by the pulse pressure is strong.

2. The pressure in the ventral aorta is ample to maintain a good and efficient circulation even in old specimens that are otherwise too weak to keep themselves from being caught on the retaining racks.

3. This ventral aortic pressure is diminished comparatively little by the branchial circulation, with the net result that the dorsal aorta has a strong pressure to drive the blood into the muscles, a fact of vital significance when viewed in connection with the migration journey of the salmon.

---

[a] Brünnings, W., Zur Physiologie des Kreislaufes der Fische. Pflüger's Archiv f. d. ges. Physiologie, 75, 1899, 599.

### REFERENCES.

RUTTER, CLOUDSLEY. Studies on the natural history of the Sacramento Salmon. Popular Science Monthly, July, 1902.

——— Natural history of the Quinnat Salmon. Bulletin U. S. Fish Commission, XXII, 1904, 65.

MIESCHER-RUESCH, FRIEDRICH. Statistische und Biologische Beiträge zur Kenntniss vom Leben des Rheinlachses im Süsswasser. Schweizerische Fischerei-Ausstellung zu Berlin, 1880, S. 154.

——— Histochemische und Physiologische Arbeiten. Leipzig, 1897.

HENDERSON, YANDELL. Contributions to biology from investigations on the breeding salmon. Popular Science Monthly, April, 1902. (This paper is a review of Miescher-Ruesch's contributions on the subject.)

PATON, D. NOEL. Report of investigations on the life history of the salmon in fresh water. Fishery Board for Scotland Reports, 1898.

SCHOENLEIN, K. Beobachtungen ueber Blutkreislauf und Respiration bei einigen Fischen. Zeitschrift fur Biologie, XXXII, 1895, S. 511–547.

BRÜNNINGS, W. Zur Physiologie des Kreislaufes der Fische. Pflüger's Archiv für die gesammte Physiologie, Bd. 75, 1899, S. 599.

## II. A STUDY OF THE BLOOD AND SEROUS LIQUIDS BY THE FREEZING-POINT METHOD.

The chinook salmon, spending a greater part of the individual life in the sea, yet beginning that life and ending it in fresh water, would seem to furnish an ideal subject in which to study the osmotic balances which exist between the surrounding media and the living tissues.

It is known that among marine fishes the sharks and rays[a] have blood which has a general concentration as regards its physical characteristics about equivalent to that of the surrounding sea water. Further, it has been shown that these Selachii have a certain amount of power of adaptation to varying concentration of the surrounding water. The bony fishes, on the other hand, are said to have blood which varies very little from the concentration for mammalia and other higher vertebrates. Even marine bony fishes are supposed to possess this average concentration of the blood,[b] a concentration considerably below that of the water in which the animal lives. The salmon, like all anadromous fishes, must either possess the power of adapting itself to or is not susceptible to the change produced by running from fresh water to sea water when young, and to the reverse conditions when it runs up the rivers to the spawning beds, as already mentioned.

### THE BLOOD OF SALMON FROM SALT WATER.

I collected samples of blood from 18 marine salmon during the month of July, 1902,[c] and measured the concentration of the same by the freezing-point method. The depression of the freezing point is a measure of the total molecular concentration, i. e., the concentration due to molecules and ions in solution. The conductivity was not measured in these experiments, hence I have no check on the proportionate quantity of nondissociated and of dissociated molecules. The rapid decomposition of blood when drawn is a source of error which was guarded against. Determinations made on samples which had been kept too long are not included in this report. The table of determinations is given below.

---

[a] Rodier, E., Observations et experiénces comparatives sur l'eau de mer, le sang et des liquides internes des animaux marins; Travaux des labor. de la stat. zool. d'Arcachon, 1899, 103–123. See also Compt. Rendus, 131, 1900, p. 1008.

[b] Griffiths, A. B., Physiology of the Invertebrata, New York, 1892, pp. 140–141, says that the blood of marine bony fishes does not contain more soluble salts than the blood of fresh-water fishes. Bottazzi, Archives italiennes de Biologie 28, p. 61, finds the concentration to be intermediate between that of the blood of sharks and of air-breathing animals.

[c] I have to thank the Sacramento River Packers' Association for the privilege of working at their Monterey wharf and for many courtesies extended.

TABLE IX.—*Showing the depression of the freezing point produced by blood from marine salmon taken at Monterey, Cal.*

| Date. | No. of specimen. | Depression of the freezing point of blood. |
|---|---|---|
| 1902. | | C. |
| July 15 .. | 108 | 0.792 |
| July 15 .. | 109 | 0.811 |
| July 15 .. | 111 | 0.778 |
| July 16 .. | 112 | 0.761 |
| July 16 .. | 113 | 0.726 |
| July 16 .. | 114 | 0.752 |
| July 21 .. | 131 | 0.700 |
| July 23 .. | 135 | 0.745 |
| July 23 .. | 141 | 0.770 |
| July 23 .. | 144 | 0.796 |
| July 23 .. | 148 | 0.754 |
| July 23 .. | 149 | 0.772 |
| July 25 .. | 160 | 0.782 |
| July 26 .. | 170 | 0.733 |
| July 27 .. | 173 | 0.786 |
| July 27 .. | 174 | 0.753 |
| July 27 .. | 175 | 0.713 |
| July 27 .. | 179 | 0.785 |
| Mean for 18 specimens.................. | | −0.762 |

These samples were taken from selected fish as they came in to the Packers' wharf from the fishing grounds. All were medium and large fishes and were fresh, some still giving signs of life. The minimal depression of the freezing point was given by No. 31, −0.700° C.; the maximal depression by No. 9, −0.811° C. The mean depression of the series is −0.762° C., which represents a concentration of the blood equivalent to a 1.26 per cent solution of sodium chloride, assuming a dissociation of 86 per cent at this concentration.[a] The depression of the freezing point produced by the sea water taken from the fishing grounds of Monterey Bay is −1.924° C. Compared with sodium chloride this concentration is the equivalent of 3.20 per cent, or two and one-half times the concentration of the salmon's own blood. As a matter of fact the osmotic pressure of the sea water will be somewhat less, since the dissociation of the different salts will be not quite so great as sodium chloride. The fact I want to emphasize is obvious, namely, that the total osmotic pressure remains far above that of the salmon's blood.

The above showing justifies the conclusion that the thin epithelial layer of cells which separates the blood in the gills from the surrounding sea water does not admit of free diffusion of substances in solution in the blood on the one side and in the sea water on the other. Respiratory exchange of oxygen and carbon dioxide takes place through the gills between the blood and the sea water. The salts, however, can not freely pass. Even as diffusible a substance as sodium chloride is no exception to the rule, the gill epithelium being impermeable to it. In the absence of a chemical analysis of salmon blood, we may assume that the amount of sodium chloride present is considerably less than that necessary to produce a depression of the freezing point of $-0.762°$ C., i. e., the total depression due to all the blood constituents and equivalent to 1.26 per cent[a] of sodium salt (see ante). The percentage of sodium chloride present in sea water, according to an analysis of the North Sea water by Backs,[b] is 2.358 per cent in a total of 3.046 per cent of salts. Applying this analysis to the sea water of Monterey, where the salmon are taken, it is obvious that there is a difference in concentration between the sea water and the salmon blood in sodium chloride alone of a little less than 2 per cent, a difference which ought to suffice on known laws of osmosis in establishing a strong current of water from the blood to the sea water.

---

[a] Interpolated from Ostwald's tables, Lehrbuch der Allgemeine Chemie, 2te Auf.

Furthermore, the salmon are feeding constantly and voraciously at this time, a process which may introduce considerable sea water into the stomach. This is notably true at Monterey, where the chief food is the squid, the blood and body fluids of which have the concentration of sea water.[c] The skin, also, is a possible region of exchange of constituents between the blood and the sea water. Neither of these regions provides a channel by which the salts of the sea water may permanently enter the blood.

Enough has been given here to demonstrate that we do not have to deal with a question of simple osmotic balance between the sea water and the salmon's blood. Such a balance does not exist. The living epithelium of the gills does not act like an ordinary dead animal membrane; it is, in fact, a membrane impermeable, or at most permeable with great difficulty, to both water and salts. This question will be reviewed after presentation of the facts concerning the relations of the blood in fresh-water salmon from the upper streams.

### THE BLOOD OF SALMON FROM TIDE WATER.

The blood was collected from seven different specimens of salmon taken near Black Diamond, California, in August, 1902, all from the main channel off Collinsville. The water in this region at the time of my examination lowered the freezing point by only $-0.020°$ to $-0.022°$ C., an amount that is insignificant as compared with the depression of the freezing point of sea water.

---

[a] The percentage obtained by interpolation from Hedin's tables (Skand. Arch., Bd. 5, 1895, S. 381) is somewhat less, i. e., 1.22 per cent.

[b] Quoted from Griffith's Physiology of Invertebrata, p. 137, New York, 1892.

[c] Bottazzi, La pression osmotique du sang des animaux marins. Archives italiennes de Biologie, T. 28, 1897, p. 61.

Table X.—*Depression of the freezing point of blood from salmon taken in the main channel of Suisun Bay at the head of brackish water of the San Francisco Bay region.*

| Date. | No. of specimen. | Depression of freezing point of whole blood. |
|---|---|---|
| 1902. | | °C. |
| Aug. 7 | 191 | 0.780 |
| Aug. 10 | 194 | 0.772 |
| Aug. 10 | 195 | 0.691 |
| Aug. 10 | 196 | 0.679 |
| Aug. 10 | 197 | 0.744 |
| Aug. 10 | 198 | 0.766 |
| Aug. 10 | 199 | 0.727 |
| Mean | | 0.737 |

The mean depression in these seven examples is −0.737° C., a figure which differs from the mean of the sea salmon by 0.025° C. In making the run from salt water to the head of brackish water there is therefore a small fall in the osmotic tension of the blood.

In the meantime the salmon have ceased to feed. The stomachs are empty save for a thick mass of tough mucous, but no obvious changes have occurred in the gross structure of the alimentary canal. It is unfortunate that there is no definite information as to the time consumed by the fish in adapting itself to the change from salt to fresh water. It has not yet been demonstrated whether the run is direct and continuous or more slow and gradual. The most plausible explanation of the directive influences determining the rapidity with which salmon make the journey through lower tide water is given by Rutter,[a] though he ventures no conclusion as to the rapidity with which the passage through lower tide water is made. He has determined that the progress through upper tide water is comparatively rapid, the salmon making the journey from Vallejo to Sacramento in about four days. There is a belief current among the fishermen at Black Diamond that salmon spend considerable time on the Flats along the upper bay, and the muddy condition of the skin and gills of fish caught in this region would to some degree bear out this view.

Table X shows that a fall of the osmotic pressure of the blood has already begun by the time the fish have reached upper tide water, enough to depress the freezing point by −0.025° C.

### THE CONDITION OF THE BLOOD IN SALMON ON THE SPAWNING BEDS.

Salmon make the run from upper tide water to the spawning grounds at a comparatively rapid rate. Rutter[b] found that three specimens branded in the lower river at Rio Vista made the run, a distance of about 300 miles, in 65 days in two cases and in 61 days in one case. Rutter states, further, that the average duration of the spring run is six weeks, but that the fish arrive on the spawning beds from two to six weeks before spawning. From these observations it will appear that the spring run of salmon at spawning time have been in fresh water from eight to twelve weeks. I have made a large number of determinations on the blood of salmon of this class taken from the spawning beds at the United States fish hatchery at Baird, Cal., the results of which are given in Table XI.

---

[a] Rutter, Popular Science Monthly, July, 1902, p. 207.

[b] Ibid., p. 209.

TABLE XI.—*Depression of the freezing point produced by blood and serum from salmon taken on the McCloud River, Baird, Cal.*

| Date. | No. | Sex. | Length in centimeters. | Blood. | Serum. |
|---|---|---|---|---|---|
| 1901. | | | | C. | C. |
| Aug. 19.. | 25 | Female..... | .......... | ............ | −0.555 |
| Aug. 19.. | 26 | Female.. | .......... | ............ | −0.570 |
| Aug. 19.. | 27 | Female..... | .......... | −0.621 | −0.580 |
| Aug. 20.. | 28 | Male ....... | 53.0 | −0.673 | −0.662 |
| Aug. 20.. | 29 | Male ....... | 54.0 | −0.657 | −0.650 |
| Aug. 20.. | 30 | Male ....... | 55.0 | −0.663 | −0.643 |
| Aug. 20.. | 31 | Male ....... | 60.0 | ............ | −0.690 |
| Aug. 21.. | 32 | Female..... | 86.0 | ............ | −0.613 |
| Aug. 21.. | 33 | Female..... | 93.0 | ............ | −0.629 |
| Aug. 21.. | 34 | Female..... | 92.0 | ............ | −0.626 |
| Aug. 22.. | 35 | Female..... | .......... | ............ | −0.628 |
| Aug. 23.. | 39 | Female..... | .......... | −0.586 | −0.577 |
| Aug. 24.. | 40 | Female..... | 79.0 | −0.587 | −0.590 |
| Aug. 24.. | 41 | Female..... | 79.0 | −0.583 | −0.588 |
| Aug. 28.. | 52 | Female..... | 85.0 | −0.628 | −0.625 |
| Aug. 28.. | 53 | Female..... | 73.0 | ............ | −0.626 |
| Aug. 28.. | 54 | Female..... | 89.0 | ............ | −0.617 |
| Aug. 28.. | 55 | Female..... | 90.0 | ............ | −0.657 |
| Aug. 29.. | 58 | Female..... | .......... | −0.690 | ............ |
| Sept. 2... | 61 | Male ....... | 92.0 | −0.705 | ............ |
| Sept. 2... | 64 | Female..... | .......... | ............ | −0.600 |
| 1902. | | | | | |
| Aug. 19.. | 203 | Male ....... | 42.8 | −0.674 | ............ |
| Aug. 19.. | 204 | Male ....... | 45.9 | −0.690 | ............ |
| Aug. 20.. | 206 | Male ....... | 93.5 | ............ | −0.518 |
| Aug. 20.. | 207 | Female..... | 82.3 | −0.576 | −0.579 |
| Aug. 22.. | 209 | Male ....... | 91.8 | −0.613 | −0.556 |
| Aug. 23.. | 210 | Female..... | 67.2 | −0.635 | ............ |
| Aug. 23.. | 211 | Female..... | .......... | −0.644 | −0.596 |
| Aug. 23.. | 212 | Female..... | 77.7 | −0.557 | ............ |
| Aug. 25.. | 213 | Male ....... | 75.2 | −0.619 | −0.607 |
| Aug. 26.. | 214 | Female..... | 82.9 | −0.634 | ............ |
| Aug. 26.. | 215 | Female..... | 86.6 | −0.614 | ............ |
| Aug. 27.. | 219 | Male ....... | 86.0 | −0.617 | −0.602 |
| Aug. 28.. | 220 | Male ....... | 49.0 | −0.593 | ............ |
| Aug. 28.. | 222 | ............ | .......... | −0.602 | ............ |
| Aug. 29.. | 225 | Female..... | .......... | −0.638 | −0.635 |
| Aug. 29.. | 226 | Female..... | .......... | ............ | −0.605 |
| Mean of all determinations | | | | −0.628 | −0.613 |
| Mean for males | | | | −0.668 | −0.653 |
| Mean for females | | | | −0.610 | −0.605 |

The mean or average depression of the freezing point produced by the blood of salmon from the spawning beds, as shown by the above table, is −0.628° C., a figure that shows a marked falling off in the concentration of the blood when spawning salmon are compared with salt-water and tide-water salmon. The variation in the spawning-ground salmon is very great, as is to be expected when the probable great difference in time spent in fresh water is taken into consideration. Many salmon arrive on the beds during the spawning time in fine flesh and full vigor, while others which have been on the grounds for a longer time show unmistakable external signs of decreased energy and vitality. Such fish have a less concentrated blood and their tissues are notably less firm than is the case with fresh arrivals. The extremes of concentration of whole blood measured at Baird hatchery are Nos. 212 and 61, with a depression of the freezing point of −0.557° and −0.705° C., respectively. No. 212 was an artificially spawned female that was in thin flesh; No. 61 was a large prime male whose muscles were still pink and firm, a fish in full vigor. The larger number of samples of serum show an average depression of the freezing point of −0.613° C., which varies from the mean taken from whole blood determinations by about 2½ per cent only. If we consider only the 14 fish in which measurements were made on blood and on serum from the same individual, then the mean depression produced by the serum is only 1.7 per cent below that of whole blood. This difference appears almost wholly in two observations, Nos. 27 and 209, where the difference is considerable. The presence of the corpuscles in suspension in the serum in whole blood ought not to change the depression of the freezing point unless the corpuscles are disintegrating. Observations of Hamburger[a], Roth[b], Bugarsky and Tangl[c], and Stewart[d] all indicate that the corpuscles are inert in freezing determinations and nonconductors in electrical conductivity determinations. Considering the fact that the serum has essentially the same concentration as blood, then No. 206, with a serum that depresses the freezing point, −0.518° C., is the most dilute blood examined. This specimen was an old male off the retaining rack and in my list represents the specimen nearest death and disintegration. The sides of this specimen were covered with fungus patches, and the skin was broken on an area over the back and on the nose. These pathological conditions would tend to break down the general osmotic resistance of the skin, just as erosion of the skin permits free absorption of materials in man or the higher animals. On the other hand, one must not draw the conclusion that this is the only or even the primary factor leading to the dilution of salmon blood in fresh water. In specimen 212 the skin was clean and perfect, and the fish seemed externally in perfect condition as far as abrasions and general appearance of the skin indicate. Yet the blood gave only −0.557° C. and the ovarian fluid the remarkably low figure of −0.429° C., some 0.12° below the general average of the series. The lower the vitality of the tissues for whatever cause the more dilute the blood was found to be.

If salmon blood be allowed to stand for a day in a warm room, then the corpuscles break up in large quantities and the increased number of ions and molecules set free will of course increase the depression of the freezing point. Experiments in which there was evidence of such change were discarded and do not appear in the above considerations, as stated before. On the whole, the variations in the above table are to be explained as due to the different condition of the individuals studied, differences due to different times of sojourn in fresh water, differences in sex, vitality, etc.

The difference in the blood of males and of females is especially noticeable. The average depression for the whole blood of males is −0.668° C., and for serum −0.653°. The average for females is −0.610° and −0.605° C. for blood and for serum, respectively. This variation in the sexes amounts to about 8⅔ per cent—i. e., the female blood, as determined above, is 8⅔ per cent less concentrated than male blood and the serum 7⅓ per cent less. I believe this observation has its explanation in the more profound changes taking place in the development of the large mass of the ovary as compared with the relatively smaller mass of the testes, and in connection with the production of the large quantity of ovarian fluid at the time of the ripening of the eggs.

---

[a] Hamburger, H. J., Ueber die Regelung der osmotischen Spannkraft von Flüssigkeiten in Bauch- und Peritonealhöhle. Archiv f. Anat. u. Physiologie, Physiol. Abt., 1895, S. 281.

[b] Roth, Wm., Electrische Leitfähigkeit thierischer Flüssigkeiten. Virchow's Archiv, Bd. 154, 1899, S. 466.

[c] Bugarsky and Tangl, Untersuchungen über die molecularen Concentrations-Verhältnisse des Blutserums. Centralb. f. Physiologie, Bd. XI, 1897, S. 301.

[d] Stewart, G. N., Elektrische Leitfähigkeit thierischer Flüssigkeiten. Centralb. f. Physiologie, Bd. XI, 1897, S. 332.

### THE OVARIAN LIQUID FROM MATURE FEMALE SALMON.

A quantity of serous liquid, the ovarian fluid of Miescher-Russch, is always found in the abdominal cavity of the ripe females, the liquid being extruded with the eggs. This liquid is easily collected during the artificial spawning. It amounts to from 100 to 150 cubic centimeters, but varies greatly in quantity in different individuals.

Determinations of the freezing point were made on series of samples of this ovarian liquid in the summers of 1901 and 1902. Females to be spawned were very carefully freed from excess of water by wiping with dry cloths and the eggs spawned into a clean dry spawning pan. The liquid extruded with the eggs was strained through dry cleansed cheese-cloth into prepared bottles. The method of collecting did not admit of contamination at any point. The depression of the freezing point produced by these samples is given in the table below:

TABLE XII.—*Depression of the freezing point produced by the ovarian liquid from ripe salmon from the spawning beds at Baird, Cal.*

| Date. | No. | Depression of the freezing point. |
|---|---|---|
| 1901. | | C. |
| Aug. 23 .. | 36 | △= 0.553 |
| Aug. 23 .. | 37 | 0.560 |
| Aug. 23 .. | 38 | 0.563 |
| Aug. 24 .. | 40 | 0.536 |
| Aug. 24 .. | 41 | 0.552 |
| Aug. 24 .. | 42 | 0.555 |
| Aug. 24 .. | 43 | 0.533 |
| Aug. 28 .. | 51 | 0.545 |
| Aug. 28 .. | 52 | 0.546 |
| Aug. 28 .. | 53 | 0.563 |
| Aug. 28 .. | 54 | 0.562 |
| Aug. 28 .. | 55 | 0.599 |
| Aug. 27 .. | 56 | 0.528 |
| Aug. 29 .. | 58 | 0.531 |
| Aug. 30 .. | 60 | 0.562 |
| Aug. 31 .. | 62 | 0.571 |
| Aug. 31 .. | 63 | 0.575 |
| 1902. | | |
| Aug. 20 .. | 207 | −0.559 |
| Aug. 23 .. | 211 | 0.548 |
| Aug. 23 .. | 212 | 0.429 |
| Aug. 26 .. | 214 | 0.550 |
| Aug. 26 .. | 215 | 0.539 |
| Aug. 29 .. | 225 | 0.571 |
| Aug. 29 .. | 226 | −0.555 |
| Mean of 24 specimens .......... | | −0.549 |

The determinations reported in this table are remarkable for uniformity in result. There is only one noteworthy exception to the statement, viz., No. 212. In this fish the concentration of the ovarian liquid is exceptionally low. By reference to Table XI it will be seen that the blood of this fish also is very low, being −0.072° C. below the average in concentration. Leaving aside the ovarian fluid of No. 212, then the averages of determinations on the ovarian liquids for the two seasons agree within one point in one thousand, being −0.555 and −0.554 for 1901 and 1902, respectively. The concentration of the liquid from the abdominal cavity is less than that of the blood or the serum. The following tables give sets of determinations made on the ovarian fluid, the serum, and the whole blood from the same animal (Table XIII), and on the serum and ovarian liquid (Table XIV).

TABLE XIII.—*Depression of the freezing point produced by the blood, the serum, and the ovarian fluid from the same animal.*

| Date | No. | Blood. | Serum. | Ovarian fluid. |
|---|---|---|---|---|
| 1901. | | ° *C.* | ° *C.* | ° *C.* |
| Aug. 24 | 40 | △=−0.586 | △=−0.590 | −0.538 |
| Aug. 24 | 41 | −0.583 | −0.588 | −0.552 |
| Aug. 28 | 52 | −0.628 | −0.625 | −0.546 |
| 1902. | | | | |
| Aug. 20 | 207 | −0.576 | −0.579 | 0.559 |
| Aug. 23 | 211 | −0.614 | −0.596 | 0.548 |
| Aug. 29 | 225 | −0.638 | −0.635 | 0.571 |
| Mean for 6 | | −0.604 | −0.602 | 0.552 |

TABLE XIV.—*Depression of the freezing point produced by the serum and by the ovarian fluid from the same fish.*

| Date. | No. | Serum. | Ovarian fluid. |
|---|---|---|---|
| 1901. | | C. | C. |
| Aug. 24 | 40 | △=−0.590 | −0.538 |
| Aug. 24 | 41 | −0.588 | 0.552 |
| Aug. 28 | 52 | −0.625 | 0.546 |
| Aug. 28 | 53 | −0.626 | −0.563 |
| Aug. 28 | 54 | −0.617 | −0.562 |
| Aug. 28 | 55 | −0.651 | 0.599 |
| 1902. | | | |
| Aug. 20 | 207 | −0.579 | −0.559 |
| Aug. 23 | 211 | −0.596 | −0.548 |
| Aug. 29 | 225 | −0.635 | −0.571 |
| Aug. 29 | 226 | −0.605 | −0.555 |
| Mean for 10 | | −0.611 | −0.559 |

These tables, together with Tables XI and XII, demonstrate that the ovarian fluid has an average concentration less than that of the blood or serum of from 0.060° C. to 0.080° C. The ovarian fluid in those fish in which the serum also was measured has a mean or average depression of the freezing point less than that of the serum by 0.052° C. In the six instances in which the whole blood and the serum also were determined the difference between the serum and ovarian liquid is 0.054° C.; between the whole blood and ovarian fluid, 0.056° C.

Considering all the determinations on female salmon the mean difference becomes somewhat more, viz., 0.056° and 0.061° C., respectively. (See Tables XI and XII.) On the evidence at hand it would appear that the ovarian liquid bears a constant difference in concentration, represented by a difference in the freezing point, of from 0.050° to 0.060° C. less than that of the blood plasma of the same animal.

The origin of the ovarian fluid in the salmon needs further investigation. In the one unripe female which I used in experiments, in which the eggs were not yet set free in the body cavity, the eggs were free from excess moisture and there was no appreciable amount of liquid in the abdominal cavity. Mr. G. H. Lambson, the superintendent of Baird Station, writes me in response to my inquiry:

> We have opened many females before the eggs were ripe, but never have noticed any egg fluid in them. The eggs before they separate are rather dry and do not wet the fingers. When we open the green females it is to secure the eggs for fishing and we may have overlooked the fluid, but from the fact that the eggs are practically dry I should think none was present.

I have seen such females opened, but no liquid was present. Males do not contain more than a few drops of abdominal cavity liquid. In one of the largest male specimens used not enough liquid could be obtained from the body cavity for a freezing determination.

The ovarian liquid is a clear, limpid, slightly translucent fluid very like mammalian transudates, hydrocoele fluid for example, in appearance. It makes its appearance when the eggs are being set free from the ovary and following this event. Paton[a] gives a quotation from Miescher-Reusch containing the phrase "the ovarian fluid which readily exudes from the ripe ovary when broken down." Miescher-Ruesch[b] says that this ovarian fluid is a rich concentrated liquid to be regarded chemically as a "liquid caviar." He says that the fluid gives the proteid reactions, that it is rich in phosphorized fat (lecithin), containing as much as 20 per cent, and that on digestion with artificial gastric juice it gives a further yield of phosphorus derived from nucleo-proteid. The ovarian fluid in the chinook salmon is much more fluid and less concentrated than in *Salmo salar*, if one can rely on the observations referred to above.

At the time when the eggs are set free in the body cavity there is a very profound rupture of the surface of the ovary. There are from 4,000 to 6,000 and even more eggs in each ripe female, hence it is obvious that the entire surface of the ovary is involved in this morphological disturbance. So large a ruptured surface would furnish an ideal condition for the transudation of materials from the blood and the tissues. It is probable also that some of the liquid comes from liquefaction processes in the ovary itself antecedent to and resulting in the freeing of the eggs, though the quantitative relations do not justify the assumption that this latter source accounts for more than a fractional part of the total liquid. Hedin[c] calls attention to the close correspondence in osmotic tension of blood and transudates, a relation which does not exist between the blood and secretions, a correspondence close enough in this instance to class the ovarian fluid as a transudate. I have not seen indications of the presence of blood pigment in the ovarian liquid which would indicate rupture of blood vessels in the ovary. True, the blood is sometimes present in the artificially spawned mass of eggs and fluid, but always under conditions that point to artificial rupture of vessels (usually in the spleen) by the mechanical pressure of spawning. Occasionally the ovarian fluid has a slight yellow color the same as that of the eggs. This color is attributed to the rupture and disintegration of eggs in the body cavity itself.

## COMPARISON OF THE FREEZING POINTS OF BLOOD OF SALMON FROM THE DIFFERENT REGIONS.

The average depression of the freezing point of the salmon blood is, for sea salmon, −0.762° C.; for brackish-water salmon, −0.737° C., and for spawning-ground salmon, −0.628° C. The decrease in concentration for the second and third groups, compared with the first as a standard, is represented by −0.025° C. and −0.134° C., respectively, or a decrease of 3.3 per cent for brackish-water salmon and 17.6 per cent for spawning-ground salmon. This decrease of 17.6 per cent in blood concentration is very significant from two very different points of view. First, because the change is as small as it is, considered in relation to so profound a change in environment as that represented by a passage from sea water to fresh water. This change made suddenly is well known to be fatal to many sea forms. The cyclostome *Polistotrema stouti*,[a] when transferred to sea water diluted one-half with fresh water, dies in a few minutes with violent swimming and struggling. The blood of this cyclostome, however, has a concentration about the same as that of the sea water in which it lives. In three samples determined in July, 1901, the average depression of the freezing point for *Polistotrema stouti* serum is −1.966° C., as against −1.924° C. for the water of Monterey Bay, in which it lives. This form can not make the transition suddenly, at any rate. The related lampreys are anadromous, and it will be interesting to see what is the concentration of lamprey blood. Marine invertebrates can not safely be transferred to fresh water. In this group, however, as Bottazzi[b] and others have shown, the blood has the concentration of sea water. Quinton[c] found that the blood of marine invertebrates takes the concentration of the bathing liquid when placed in water of greater or less concentration than sea water—that is, that the skins are permeable to both salts and water. Garrey[d] has just shown that blood or body fluids of certain marine invertebrates varies not more than 0.02° C. in its freezing point from that of the water in which they live. He tested the following: *Thyone briareus*, *Arbacia punctulata*, *Asterias vulgaris*, *Sycotypus canaliculatus*, *Venus mercenaria*, *Mya arenaria*, *Homarus americanus*, and *Limulus polyphemus*. He also shows that the external tissues of these animals are permeable. Mosso[e] found that sharks (*Scyllium*) transferred to fresh water died within an hour. In fact, the circulation ceased at the end of one-half hour, though the heart still contracted, the blocking of the circulation being due to clogging of the vessels of the gills. Bottazzi also points out that in marine bony fishes the blood has a far less concentration than in invertebrates or in cartilaginous fishes, a fact which I can confirm for all three groups. He makes the point that bony fishes show an intermediate position in this regard between cartilaginous fishes and air-breathing vertebrates in that they have acquired a certain degree of independence of their surroundings. Garrey was unable to demonstrate permeability of the tissues of *Fundulus* when transferred from sea water to fresh water.

---

[a] Paton, D. Noel, Report of the Fishery Board for Scotland, 1898, p. 143.

[b] Miescher-Ruesch, F. Statistische und Biologische Beiträge zur Kenntniss vom leben des Rheinlachses im Süsswasser. Schweizerischer Fischerei-Ausstellung zu Berlin, 1880, 154.

[c] Hedin, S. G., Skand. Archiv f. Physiologie, 5, S. 277.

The salmon show a very decided independence in the relation between the composition of the blood and the surrounding water. Their gills and skin are impermeable—the exception, of course, being the permeability to oxygen and carbon dioxide. At first thought one would be inclined to ascribe the fall of concentration of the blood of 17.6 per cent to direct absorption of water in fresh water, but such is not necessarily the inference. The absence of food and the important metabolisms occurring during the eight to twelve weeks' sojourn in fresh water are to be considered in this connection, and possibly are sufficient to account for the change.

---

[a] This interesting species has been the subject of a number of valuable physiological and morphological papers. It was originally described under the name *Bdellostoma stouti* Cooper, and has been identified with *Bdellostoma dombeyi* by several authors.

[b] Bottazzi, La pression osmotique du sang des animaux marins, Arch. ital. de Biol. 29, 1897, 61.

[c] Quinton, M. R. Communication osmotique chez l'invertebres marin normal, entre le milieu interieur l'animal et le milieu exterieur. Comptes Rendus, 131, 1900, 905.

[d] Garrey, Walter E. Osmotic pressure of sea water and of the blood of marine animals. Biol. Bull., VIII, 1905, 257.

[e] Mosso, Ueber verschiedene Resistenz der Blutkörperschen bei verschiedenen Fischarten, Biol. Centralb. Bd. 10, 1890, S. 570.

The second consideration of the fall of concentration of the blood is in regard to its effect on tissue metabolism and tissue life. Observations on vertebrates have shown that while the concentration of blood may temporarily vary sharply, owing to the taking of water with the food or during abstinence from water and food, still on the whole the concentration is remarkably constant, as Roth[a] has already emphasized. This constancy in physical condition, or isotonicity, is in fact regarded as a prime physiological necessity for the normal life and activities of the tissues.

The salmon undergoes a permanent alteration of 17.6 per cent, almost one-fifth, in the concentration of the blood, yet it is able to carry on vigorous activities of the muscular and nervous systems, as well as those internal metabolisms which result in the growth and development of the ovaries and testes and which involve a transference of materials in large amount to these organs from other parts of the body, especially from the muscles. The question may be raised, Is this decrease in the proportion of solids in the blood really injurious; and if so, how far may it proceed before death takes place? An indication of the limits to this process is given by specimen No. 206, an old male too weak to keep off the retaining rack, from whence I removed it on Aug. 20, 1902. This salmon remained alive long enough to secure a blood-pressure measurement. The serum depressed the freezing point by only −0.518° C., representing a fall in concentration of 32 per cent in comparison with blood from the marine salmon. Basing judgment on this single case, one would say that a 32 per cent decrease in blood concentration represents the approximate limits of blood dilution which will support the organized life of the individual.

A reference table of the determinations of the freezing points made by different observers on the blood and serum of divers species of animals is here presented. It is not exhaustive, but represents the results given in the papers available, together with some determinations of my own not previously published. Among the Selachii and marine invertebrata, where the blood concentration follows closely that of the sea water in which they live, obviously one must in making comparisons take the environment into consideration.

---

[a] Roth, Virchow's Archiv, Bd. 154, 1899, S. 488.

TABLE XV.—*The depression of the freezing point produced by the blood and serum from different animals as presented by various observers.*

| Animal. | Blood. | Serum. | Observer. |
|---|---|---|---|
| | °C. | °C. | |
| Man | | Δ 0.560 | Dresser.[a] |
| | | -0.560 | Korányi.[b] |
| Horse | Δ 0.580 | 0.585 | Hamburger.[c] |
| | | 0.596 | Do.[d] |
| | | −0.565 | Winter.[e] |
| | | −0.530 | Bugarsky and Tangl.[f] |
| Dog | 0.599 | 0.605 | Hamburger.[c] |
| | | −0.565 | Winter.[e] |
| | | −0.587 | Bugarsky and Tangl.[f] |
| Cat | | 0.617 | Do.[f] |
| Pig | 0.625 | 0.621 | Hamburger.[c] |
| | | 0.550 | Winter.[e] |
| | | −0.598 | Bugarsky and Tangl.[f] |
| Ox | 0.601 | 0.600 | Hamburger.[c] |
| | | -0.647 | Do.[d] |
| | | -0.550 | Winter.[e] |
| | | 0.598 | Bugarsky and Tangl.[f] |
| | | −0.592 | Hedin.[g] |
| | | −0.57 | Roth.[h] |
| Sheep | 0.662 | -0.550 | Winter.[e] |
| | | 0.57 | Roth.[h] |
| Rabbit | 0.578 | −0.580 | Hamburger.[c] |
| | | 0.570 | Winter.[e] |
| Thalassochelys caretta | | −0.615 | Bottazzi.[i] |
| Cerna gigas | | 1.035 | Do. |
| Charax puntazzo | | −1.04 | Do. |
| Scorpænichthys marmoratus | | −1.053 | Greene. |
| Oncorhynchus tschawytscha: | | | |
| Marine | −0.762 | | Do. |
| Fresh-water | −0.628 | −0.613 | Do. |
| Salmo irideus | −0.645 | −0.647 | Do. |
| Torpedo marmorata | −2.26 | −2.29 | Bottazzi.[i] |
| Mustelus vulgaris | −2.36 | | Do. |
| Trigon violacea | −2.44 | −2.43 | Do. |
| Raja occidentalis | | −1.996 | Greene. |
| Polistotrema stouti | | −1.996 | Do. |
| Tautoga onitis | 0.86 | | Garrey.[k] |
| Cynoscion regalis | 0.86 | | Do. |
| Leptocephalus conger | 0.80 | | Do. |
| Anguilla chrisypa | 0.90 | | Do. |
| Xiphias gladius | 0.90 | | Do. |
| Mustelus canis | 1.86 | | Do. |
| Carcharias littoralis | 1.88 | | Do. |
| Octopus vulgaris | | −2.29 | Bottazzi.[i] |
| Octopus macropus | | −2.314 | Do. |
| Aplysia limacina | | −2.34 | Do. |
| Aplysia depilans | | −2.32 | Do. |
| Homarus vulgaris | | −2.292 | Do. |
| Maja squinado | | −2.36 | Do. |
| Sipunculus midus | | −2.31 | Do. |
| Holothuria tubulosa | | −2.315 | Do. |
| Asterias glacialis | | −2.295 | Do. |
| Astropecten auriantiacus | | −2.312 | Do. |
| Alcyonarium palmatum | | −2.196 | Do. |
| Sea water, Bay of Naples, Mediterranean. | | −2.29 | Do. |
| Sea water from Monterey Bay, Pacific Ocean. | | −1.924 | Greene. |
| Sodium chloride: | | | |
| 1 per cent | | −0.606 | Hamburger.[d] |
| 3.783 per cent | | −2.29 | Bottazzi.[i] |

[a] Dresser, Arch. f. exp. Pathol. u. Pharm., Bd. XXIX, 1892, S. 306.

[b] Korányi, Centralb. f. Physiologie, Bd. VIII, 1894, S. 503.

[c] Hamburger, Archiv. f. Anat. u. Phys., Phys. Abt., 1895, S. 281.

[d] Hamburger, Centralb. f. Physiologie, Bd. VII, 1894, S. 758.

[e] Winter, Arch. de Physiol., 1895. (This reference and the figures quoted are taken from Richet's Dictionaire de Physiologie, T. 4, p. 595.)

[f] Bugarsky and Tangl, Centralb. f. Physiol., Bd. XI, 1897, S. 301.

[g] Hedin, Skand. Arch. f. Physiol., Bd. 5, 1895, S. 277.

[h] Roth, Virchow's Archiv., Bd. 154, 1899, S. 466. Centralb. f. Physiol., Bd. XI, 1897, S. 271.

[i] Bottazzi, Arch. italien de Biol., T. 28, 1897, p. 61.

[k] Garrey, Biol. Bull., VIII, 1905, 257.

CONTRIBUTIONS FROM THE BIOLOGICAL LABORATORY OF THE BUREAU OF FISHERIES,
AT WOODS HOLE, MASSACHUSETTS.

# THE AMPHIPODA OF SOUTHERN NEW ENGLAND.

By S. J. HOLMES, Ph. D.,
*Assistant Professor of Zoology, University of Wisconsin.*

CONTRIBUTIONS FROM THE BIOLOGICAL LABORATORY OF THE BUREAU OF FISHERIES AT WOODS HOLE, MASSACHUSETTS.

# THE AMPHIPODA OF SOUTHERN NEW ENGLAND.

By S. J. HOLMES, Ph. D.,
*Assistant Professor of Zoology, University of Wisconsin.*

## INTRODUCTION.

The present paper includes descriptions of all the species of Amphipoda known to occur on the southern coast of New England. In addition, many species have been described which thus far have been found on the New England coast only north of Cape Cod; but it is probable that many of these will subsequently be discovered within the territory covered by this report.

Many of the species of Amphipoda of southern New England were described by Professor Smith in Verrill and Smith's valuable report on the Invertebrate Animals of Vineyard Sound, published in 1873. I have been able, however, to add materially to the number of species mentioned in this work, both by the description of several new species and the discovery of many others heretofore known only from other localities. In the perplexities and difficulties involved in the classification of amphipods, I have received great assistance from Doctor Stebbing's report on the Amphipoda of the Voyage of the Challenger and the volumes on the Amphipoda in Sars's Crustacea of Norway. Only by working through a mass of miserable and fragmentary description, which it falls to the lot of every systematist to peruse, is one qualified properly to appreciate such thorough and scholarly productions as these two works.

I have not thought it necessary to include an extensive synonymy of the species described, and only those references have been given which are necessary properly to connect the descriptions with work that has been done before. A bibliography is added which lists the principal papers dealing with the amphipod fauna of the region covered and of adjacent territory.

It is a pleasure to acknowledge the courtesies received during the preparation of this paper from Dr. H. C. Bumpus, formerly director of the laboratory of the Bureau of Fisheries at Woods Hole, Mass. My thanks are due also to the Boston Society of Natural History for the loan of many valuable specimens, to Prof. J. S. Kingsley for several specimens borrowed from Tufts' College, and to Prof. S. I. Smith, of Yale University, for the opportunity to examine the types of some of his species.

Valuable aid was received both in the way of specimens and literature from the United States National Museum and the Bureau of Fisheries, and is gratefully acknowledged. The photographs of the species illustrated in the plates were taken in the zoological laboratory of the University of Michigan.

The Amphipoda are found in practically all parts of the ocean. Many species are confined to near the shore, where they live among rocks and seaweeds. Others are strictly pelagic in habit, such as most of the Hyperiidea, which occur, often in very great numbers, at or near the surface of the open ocean. The Gammaridea also occur in great abundance, especially in the Arctic regions, where they assume, as a rule, a larger size than in more southern waters.

Little that is definite is known concerning the rôle played by the Amphipoda in the bionomic relations of marine life, but there can be small doubt that it is an important one. In addition to living upon the seaweeds and the bodies of dead animals, amphipods actively prey upon smaller forms of life. In turn, they fall victims to the rapacity of higher organisms. They are preyed upon by many kinds of fishes, of whose food they constitute a not inconsiderable proportion. The variety of their habitats and the great abundance they sometimes attain render them important elements in the food supply of many higher marine animals.

## GENERAL CHARACTERS OF THE AMPHIPODA.

Malacostraca, in which the body is divided into a head, a thorax of seven free segments, and an abdomen, which consists typically of six segments and a telson; no carapace; eyes sessile and usually compound; gills in the form of sacs attached to the inner side of the first joint of the thoracic legs; first three pairs of abdominal appendages fitted for swimming; the last three pairs very different from the preceding ones in structure, directed backward, and adapted for springing.

With the exception of the terrestrial sand-fleas, belonging to the Orchestiidæ, all of the Amphipoda are aquatic and the great majority of the species marine.

## EXTERNAL STRUCTURE OF AMPHIPODA.

In order to facilitate the identification of species by those who may not be familiar with this group of Crustacea, I have inserted the following account of those structural features which are commonly used in classification:

*Divisions of the body.*—The body of an amphipod crustacean is divisible into three principal parts—head, thorax, and abdomen. The segments composing the head are indistinguishably fused, and there is some difference of opinion regarding the number of segments of which the head is constituted. It is certainly as many as six; according to Della Valle, and to some others, it is seven; and Westwood puts the number as high as nine. But there is not, I believe, sufficient evidence, either anatomical or embryological, to justify us in recognizing more than seven cephalic segments, if, indeed, that many. The term head, as Doctor Stebbing has remarked, is one of rather loose application. What is termed the head in the Amphipoda corresponds to the head plus the first thoracic segment in the Decapoda. In most of the Amphipoda the head is very sharply marked off from the thorax. In one group, however, the Caprellidea, the first thoracic segment is more or less completely fused with the head, but the line of union is usually clearly indicated on the outer surface. The thorax is composed of seven free segments, each of which, except in some of the Caprellidea, bears a pair of appendages. The abdomen in the typical Amphipoda consists of six segments and a small terminal appendage, the telson, which perhaps represents an additional segment. The segments of the abdomen are usually free, but in some forms the last two may be fused. In the Caprellidea the abdomen is reduced to a mere rudiment.

*Eyes.*—The eyes of amphipods are sessile and generally compound. In the Ampeliscidæ there are instead of two compound eyes usually four eyes, each with a simple corneal lens. The eyes of the Hyperiidea are frequently of enormous size, covering most of the surface of the head. In *Phronima* they are distinctly separated into upper and lower divisions.

*First antennæ.*—The first antennæ are composed of a basal portion, or peduncle, which never consists of more than three joints and a terminal, usually multiarticulate, flagellum. A secondary flagellum is often present, but is generally of small size.

*Second antennæ.*—The peduncle of the second antennæ consists typically of five joints. In the second joint occurs the opening of the antennal gland, which is generally indicated by a conical prominence. The flagellum is generally long and slender, but in some forms it is short and stout and employed in locomotion. Both pairs of antennæ bear setæ, and often olfactory clubs and peculiar slipper-shaped appendages called calceoli.

*Upper lip.*—This is a plate articulated in front of the mandibles. Its form varies greatly in different groups.

*Mandibles.*—The mandibles of amphipods are strong and adapted for cutting and grinding. On the outer surface is inserted the palp, which never consists of more than three joints and may be reduced to two or even one. In many forms it is absent entirely. The inner edge of the mandibles is generally divided into teeth. Below the principal cutting edge is usually a smaller secondary plate, which is movably articulated and generally dentate. On the concave surface of the mandible there is usually a large molar tubercle with a roughened, rasping surface. In some forms (Lyssianassidæ) the molar tubercle may be small or absent. The right and left mandibles commonly differ in structure.

*Lower lip.*—This consists of two principal lobes fused for a certain distance in the middle line.

*First maxillæ.*—The first maxillæ consist of an inner plate, an outer plate, and a palp. The inner plate is smaller than the outer and is frequently very much reduced in size, or absent. The outer plate is elongated and tipped with a row of stout, curved, and usually denticulated or pectinate spines, which are employed in mastication. The palp consists of two joints or less. In *Orchestia* and some other genera it is absent.

*Second maxillæ.*—The second maxillæ are slender and weak and consist of a basal piece, upon which are joined an inner and an outer plate. These are generally flexible and setose on the margins.

*Maxillipeds.*—The maxillipeds consist typically of an inner plate, an outer plate, and a palp. The first joints of the right and left maxillipeds are fused in the middle line. The inner and outer plates are formed by the anterior expansion of the second and third joints, respectively; the remaining joints, four in number or less, constitute the palp. Both inner and outer plates are frequently furnished with stout spines, which are employed in mastication.

*Thoracic legs.*—The first two pairs of thoracic legs differ considerably in structure from the succeeding appendages and are designated gnathopods. The remaining five pairs are called the peræopods. Each thoracic appendage consists of seven joints, which may be designated, counting from the articulation with the body, as the coxal plate, basal joint, ischium, merus, carpus, propodus, and dactyl. The first joint or coxal plate is joined so as to permit only a small amount of lateral movement, and lies mainly outside the following joints, so that it apparently does not form a part of the appendage. The basal joint is elongated. The ischium, except in the posterior gnathopods of the Lysianassidæ, is short. The three following joints vary greatly in their relative development in the different groups. The terminal joint or dactyl is usually in the form of a claw. Only very rarely is it absent (*Haustorius*, *Bathyporeia*). The gnathopods usually have the propodus in the form of a hand, and are adapted for grasping objects, although in many forms they are also employed in ordinary locomotion. The structure and relative size of the gnathopods vary exceedingly in different groups. In some cases the dactyl closes against a thumb-like process of the hand, as in the claw of the lobster, and in such cases the gnathopods are said to be chelate. Usually the dactyl closes against one margin of the hand, the palm, and then the gnathopods are said to be subchelate. Marked sexual differences are common in structure as well as in the size of the gnathopods, and in several species (*Jassa*, some *Orchestias*) a dimorphism occurs in the second gnathopods of the male. The genus *Batea* is unique in having the first gnathopods in a rudimentary form.

*Peræopods.*—The first two pairs of peræopods are usually of similar form and nearly equal size. They are generally smaller and less stout than the following pairs and have a narrow basal joint. Their coxal plates, like those of the gnathopods, are generally large. The dactyls in nearly all amphipods point backward. In many genera which Della Valle unites under the family "Corotidi" the first two pairs of peræopods contain glands which may extend from the second into the fifth joint and which produce a sticky fluid which is discharged through a duct opening at the tip of the dactyl. This fluid, which hardens into a sort of web as it is drawn out of the duct, is used in the construction of tubes or nests in which the animal takes up its abode. The following three pairs of peræopods usually have small coxal plates and broad basal joints. They are generally of unequal size and in many genera are very dissimilar in form. The dactyls usually point forward.

*Abdominal appendages.*—The abdominal appendages of amphipods fall under two very different types. The anterior three pairs, the pleopods, are adapted for swimming. Each consists of a single basal piece which bears two multiarticulate rami, which are furnished with long, plumose setæ on both sides of each joint. The two basal pieces of each pair are held together by a series of coupling spines on the lower portion of the inner margin. The three posterior pairs of appendages, or the uropods, are firm in texture and comparatively immobile. They all point posteriorly and are closely approximated. Each consists of a basal piece, or peduncle, and two rami, which are generally uniarticulate, although in some forms the outer ramus consists of two joints of which the terminal one is usually small. Both peduncle and rami are generally armed with strong spines along the upper margins and at the tip. The terminal pair of uropods is frequently quite different in form as well as size from the preceding pairs. The outer ramus is sometimes greatly elongated while the inner one is rudimentary (*Melita*, *Niphargus*, and a few other genera). In many genera the inner ramus is completely lacking (*Orchestia*, *Corophium*, the Stenothoidæ). A great many amphipods, on the other hand, have the outer ramus of all the uropods shorter than the inner one. Very rarely (*Cerapus*) the second uropods are uniramous as well as the third. In *Pereionotus* the uropods are reduced to two pairs. The Caprellidæ, owing to the rudimentary condition of the abdomen, possess at most two pairs of abdominal appendages, and these much reduced in size. In some members of this group the abdomen is entirely devoid of appendages.

*Gills.*—The gills of amphipods are in the form of flattened sacs which depend from the inner side of the coxal plates of the thoracic legs. They are usually confined to the last six pairs of thoracic appendages, but are lacking in different segments in different groups.

*Marsupial pouch.*—The eggs of the Amphipoda are carried in a pouch under the thorax of the female. This pouch is formed by overlapping lamellæ which arise inside the base of the second to the fifth thoracic appendages. In some forms there are less than four plates, but it is very rare that there are five. Each lamella is generally more or less spatulate in form and bears on the margins very long plumose setæ, which serve to hold the plates together.

The following abbreviations are used in connection with the figures in the text:

*ant*$_1$......first antenna.
*ant*$_2$......second antenna.
*gn*......gnathopod.
*p*......peræopod.
*T*......telson.
*ur*......uropod.

## Tribe HYPERIIDEA.

Head generally large, often with enormously developed eyes; maxillipeds with the inner plates coalesced; palp wanting; gnathopods not very large, coxal plates small; last two abdominal segments fused.

The Hyperiidea are pelagic forms and are often found in association with medusæ, or, more rarely, other pelagic animals. The species often have a very wide range, and it would not be surprising, therefore, if forms were met with off the coast of New England which had previously been recorded only from a far distant locality. Nearly all the known species of Hyperiidea are fully described and figured in the excellent Monograph of the Amphipoda Hyperiidea by Prof. Carl Bovallius. The species that have been met with near the coast of southern New England are described below.

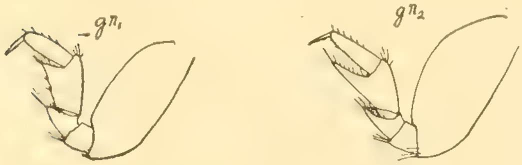
### Family HYPERIIDÆ.

Head very large and tumid, the sides entirely occupied by the enormous eyes; antennæ short and with undivided flagella in the female; with long multiarticulate flagella in the male; mandibles with a palp; gnathopods simple, subchelate, or complexly subchelate; peræopods not greatly modified; uropods biramous, with flattened lanceolate rami.

Peræopods subequal in length.
  Carpal lobe of the first gnathopods short or absent.................................HYPERIA
  Carpal lobe of the first gnathopods as long as the propodus.................................HYPEROCHE
Third peræopods markedly longer than the others.................................EUTHEMISTO

### **Hyperia galba** (Montagu.)

Body tumid; antennæ in the female scarcely half as long as the depth of the head, the first a little longer than the second; in the adult male both antennæ may exceed half the length of body; first gnathopods with carpus produced at the postero-inferior angle into a triangular pointed lobe; second gnathopods with carpus produced into a narrow triangular lobe at the postero-inferior angle extending to or beyond the middle of propodus; peræopods almost devoid of setæ; rami of terminal uropods narrowly ovate-lanceolate; telson triangular-ovate, acute. Length, 15 mm. Arctic specimens may attain a length of 20 mm.



*Hyperia galba*, male. After Sars.

Arctic regions; Norway; British Isles; France; Greenland; off Cape Breton, Nova Scotia; Grand Manan; Gulf Stream, longitude 110° 9′ N., latitude 68° 52′ W.; Eastport, Me.; Salem and Woods Hole, Mass.

Found commonly in *Aurelia*.

### **Hyperia medusarum** (Müller).

This species is closely allied to *H. galba*, but may be distinguished by the following characters: The gnathopods are larger and densely setose on the sides, while in *galba* they have almost no setæ on the surface; the postero-inferior angle of the first gnathopods is not produced, and that of the second is not produced as far as the middle of the propodus; the posterior margins of the first and second peræopods are well furnished with setæ. Length, 15 mm.

Arctic regions; Norway; Greenland; Labrador (Packard); Bass Harbor (on *Cyanea*).

Often found in *Cyanea* and *Aurelia*.

It is very probable that this species will be found as far south as Woods Hole, although I have no knowledge of its occurrence south of Cape Cod. Its usual host, *Cyanea*, is often taken farther south. Professor Smith reports two species of *Hyperia* from Vineyard Sound. It is quite probable that they were this and the preceding species.

### **Hyperoche abyssorum** (Boeck).

Body rounded above, more tumid in the female than in male; second antennæ in female much smaller than first, the latter very much shorter than the depth of head; flagellum of second antennæ not much longer than peduncle; both pairs of antennæ much elongated in male; gnathopods of similar form; carpus in both pairs produced into a long acute lobe which extends below the propodus to or beyond its distal end; first two peræopods with carpus compressed, the posterior edge acute, denticulated and produced at lower end into a tooth; three posterior peræopods subequal and not much longer than first two, but with long and slender dactyls and narrower carpi; telson triangular-ovate, not reaching the middle of peduncle of terminal uropods. Length, 5–6 mm. Artic specimens, according to Sars, may attain a length of 15 mm. All of the specimens of this species which I have examined are of small size.

Artic regions; Norway; Greenland; Labrador; Albatross station 2029; Domino Harbor.

### **Euthemisto compressa** (Goës).

Body carinated above, the carina on last two segments of thorax and the first two of abdomen produced posteriorly in adults into a tooth. First antennæ in adult female about as long as the head is deep, the tip curved downward; carpus of first gnathopods broad, but not produced at the postero-inferior angle; propodus about as long as carpus and about twice as long as dactyl; second gnathopods with carpus produced below propodus nearly to the tip; dactyl slender, but little over half the length of propodus; carpus of first and second peræopods expanded, rather narrowly but regularly oval, the posterior margin furnished with several long and stout setæ; propodus narrow, curved, little tapering, and closing against the carpus; third peræopods longer and stouter than the posterior two pairs, which reach but little farther than middle of propodus of the former; anterior margin of propodus armed with about ten setæ and minutely pectinated with very short setæ; dactyl over one-fifth the length of propodus and devoid of setæ; outer ramus of uropods much shorter than inner; telson not one-fourth the length of peduncle of terminal uropods.

Length, 12–30 mm., the latter attained by Arctic specimens.

Norway (Sars); Arctic Ocean; Greenland; Jeffries Bank, Labrador; off Marthas Vineyard, *Albatross* stations 914, 2029, 2095, 2101, 2255.

This species, like the following one, is often taken in large quantities at the surface. Frequently many hundred specimens are taken without a single adult, or numerous adults may be taken without finding a single immature individual. The teeth on the dorsal side of the thorax and abdomen are often absent entirely in the young of both species.

### **Euthemisto bispinosa** (Boeck).

Body carinated above, the carina on last two thoracic segments produced posteriorly in adults into a tooth; antennæ about as in *compressa;* first peræopods with carpus irregularly oval, much broader than in *compressa*, the posterior margin bulging strongly backward near the proximal end and furnished with several rather weak setæ; carpus of second peræopods oval, broader than in *compressa*, the setæ on posterior margin much as in first pair; third peræopods large, much elongated; carpus markedly stouter in the basal half; propodus very narrow, elongated and straight, anterior margin furnished with but few setæ, mainly on proximal portion and pectinate with minute spinules which increase in length toward distal end, where they may equal or exceed the diameter of the joint; dactyl devoid of setæ and less than one-fifth the length of propodus; uropods and telson as in preceding species.

Arctic Ocean; Finmark; Greenland; off Nova Scotia (Stebbing); Gulf of Maine; Vineyard Sound; *Grampus* station 89; Long Island.

## Family PHRONIMIDÆ.

Very deep head, on the sides and top of which are located the large eyes; antennæ attached to anterior side of head, the flagellum of both pairs multiarticulate in the male; second antennæ rudimentary in the female; no mandibular palp.

### **Phronima sedentaria** (Forskål).

Several specimens of this species, from various points off the coast of New England, were examined. They were usually found in tests of *Salpa*. The species is very extensively distributed over both the Atlantic and the Pacific oceans. The variations due to differences of age and sex are very great and have given rise to much confusion and the formation of many synonyms.[a]

## Tribe GAMMARIDEA.

Head rather small, with eyes rarely of very large size; body usually compressed; maxillipeds with inner plates free and furnished with a palp.

The Gammaridea include the typical Amphipoda. Both the Hyperiidea and the Caprellidea are to be regarded as aberrant groups, highly specialized in relation to their peculiar habits of life. The Gammaridea comprise by far the greater number of species of amphipods. The group is one of great diversity, and its proper subdivision is attended with unusual difficulties. There are extremely wide differences of opinion regarding the limits of the families into which it should be divided. In the elaborate monograph of the Gammaridea by Della Valle, all the genera are grouped into ten families; Sars distinguishes twenty-five families in the fauna of Norway alone, and several new families have been instituted by Doctor Stebbing. At present a large number of families is proposed without being grouped into anything that approaches a satisfactory system. In the present paper I have not attempted the task of grouping the genera into families, as it was not really necessary for the purpose in hand, and have inserted a key which enables one to pass directly to the genera.

---

[a] I subjoin a list of species of Hyperiidea examined from regions somewhat beyond the one covered by this paper.

*Parathæmisto oblivio* (Kröyer); *Albatross* stations 2029 and 2101.

*Cystisoma spinosum* (Fabricius), a single specimen; *Albatross* station 2199.

*Oxycephalus clausi* (Bovallius); *Albatross* station 2095.

*Anchylomera Blossevillii* (Milne-Edwards); Gulf Stream, several specimens.

*Vibilia viatrix* (Bovallius); a single specimen from off Newport.

An undetermined species of *Thyropus* is reported by Professor Smith as having been taken off Gay Head.

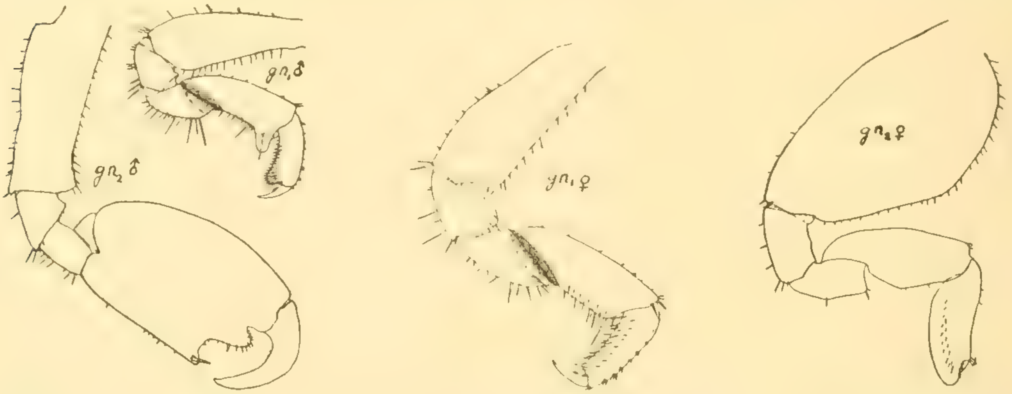
### *Key to the genera of Gammaridea.*

A. Eyes four, sometimes apparently only two (*Haploops*), each with a simple lens (Ampeliscidæ).
Terminal uropods extending much beyond the others; telson oblong, deeply cleft .................... AMPELISCA, p. 479
Terminal uropods extending but little beyond the others; telson short and broad, not deeply cleft ....... BYBLIS, p. 482
AA. Two compound eyes, or, rarely, the eyes rudimentary or absent.
B. First antennæ much shorter than the second; mandibles devoid of a palp; terminal uropods with a single uniarticulate ramus (Orchestiidæ).
C. First antennæ exceeding the tip of the peduncle of the second pair; aquatic forms ........... ALLORCHESTES, p. 472
CC. First antennæ much shorter than the peduncle of the second; terrestrial forms.
First gnathopods in both sexes subchelate ........................................................ ORCHESTIA, p. 469
First gnathopods simple in the female .......................................................... TALORCHESTIA, p. 468
BB. Without the combination of characters of B.
C. First two pairs of paræopods devoid of spinning glands.
D. Last pair of peræopods much longer than the preceding ones, with the dactyl very long and styliform; eyes nearly contiguous above, near the end of the projecting front (Œdiceridæ).
Carpus of the anterior gnathopods devoid of a prominent posterior lobe ...................... PARŒDICEROS, p. 487
Carpus of the anterior gnathopods prolonged into a long lobe which extends behind the hand ............................................................................... MONOCULODES, p. 487
DD. Without all the characters of D.
E. Rostrum produced into a hood over the antennæ. Penultimate peræopods much longer than the last pair (Phoxocephalidæ).
F. Palp of the first maxillæ two-jointed ................................................................ HARPINIA, p. 478
FF. Palp of the first gnathopods one-jointed.
Second gnathopods markedly larger than the first ................................ PHOXOCEPHALUS, p. 477
First and second gnathopods of equal size ............................................... PARAPHOXUS, p. 477
EE. Rostrum not as in E.
F. Mandibles not denticulated; palp three-jointed; first antennæ with a short, thick base and a secondary flagellum; coxal plates deep; second gnathopods elongated, slender, flexible, with the ischium elongated and the hand small and furnished with dense patches of short setæ; dactyl rudimentary (Lysianassidæ).
G. Telson entire ............................................................................... LYSIANOPSIS, p. 475
GG. Telson deeply cleft.
H. Postero-lateral angle of the third abdominal segment not produced ....................... TRYPHOSA, p. 473
HH. Postero-lateral angle of the third abdominal segment produced into a small tooth ..... HOPLONYX, p. 474
HHH. Postero-lateral angle of third abdominal segment produced into a large upturned tooth, above which is a deep marginal sinus.
Basal joints of first antennæ distally produced above; secondary flagellum small .. HIPPOMEDON, p. 473
Basal joints of first antennæ not so produced; secondary flagellum well developed .... ANONYX, p. 472
FF. Without the combination of characters of F.
G. Terminal uropods with a single ramus.
H. Ramus of terminal uropods one-jointed; first gnathopods massive, the second small ...... UNCIOLA, p. 520
HH. Ramus of terminal uropods two-jointed (Stenothoidæ).
Mandibles with a palp ........................................................................ METOPA, p. 483
Mandibles without a palp .................................................................. STENOTHOË, p. 484
GG. Terminal uropods biramous; abdomen with the last three segments free.
H. Anterior gnathopods with the carpus and propodus forming a chela ...................... LEUCOTHOË, p. 486
HH. Not as above.
I. Carpus of the gnathopods joined in front of the proximal end of the propodus ........... EUSIRUS, p. 493
II. Carpus joined in the usual manner.
J. Peræopods devoid of dactyls and peculiarly modified for digging .................. HAUSTORIUS, p. 476
JJ. Peræopods with dactyls.
K. First antennæ with an accessory flagellum.
L. Terminal uropods flattened, projecting beyond the others. Gnathopods larger in the male than in the female, the second pair generally larger than the first; telson small, flattened, cleft, or emarginate (Gammaridæ).
M. Inner ramus of the terminal uropods scale-like, rudimentary; first antennæ longer than the second ................................................................................ MELITA, p. 504
MM. Inner ramus of terminal uropods not rudimentary, although often considerably smaller than the outer.
N. Telson only slightly emarginate; thorax and abdomen dorsally carinated ........................................................................ GAMMARELLUS, p. 508
NN. Telson deeply cleft.
O. Last three segments of the abdomen with fascicles of spines.
First three abdominal segments produced behind into acute teeth .. CARINOGAMMARUS, p. 503
First three abdominal segments not so produced; abdomen not dorsally carinated .......................................................................... GAMMARUS, p. 500

OO. Last three segments of the abdomen without fascicles of spines, although there may be spiniform projections from the posterior margins of the segments.
Terminal uropods with comparatively short and broad rami.
Posterior peræopods stout........Elasmopus, p. 507
Terminal uropods elongated; posterior peræopods rather slender........Mæra, p. 525
LL. Not with all the characters of L.
M. Body spiny; secondary flagellum minute........Rhachotropis, p. 493
MM. Not as above.
Coxal plates enormously developed; body tumid; no mandibular palp..Stegocephalus, p. 482
Mandibles with palp; fourth abdominal segment with an upturned process; coxal plates of ordinary size........Pontoporeia, p. 476
KK. First antennæ with no secondary flagellum.
L. Maxillipeds with the palp small and two-jointed: parasitic; thorax rather broad and tumid........Lafystius, p. 492
LL. Not as above.
M. Telson cleft.
N. First gnathopods rudimentary........Batea, 499
NN. First gnathopods not rudimentary.
O. First three pairs of coxal plates pointed below; body with prominent spines or tubercles and a median dorsal crest; head with a very prominent rostrum.
Body with prominent tubercles on either side of the dorsal crest........Epimeria, p. 491
OO. First three coxal plates not pointed below.
Fourth abdominal segment with a posterior dorsal prominence; no mandibular palp........Dexamine, p. 498
Fourth abdominal segment without a posterior dorsal prominence; mandibular palp three-jointed........Pontogeneia, p. 476
MM. Telson not cleft.
N. Body dorsally carinated.
O. Abdomen with tubercles or spines on either side of the dorsal carina.
P. Postero-lateral margins of the abdominal segments with very large spines........Acanthozone, p. 491
PP. Postero-lateral margins of the abdominal segments with tubercles but no large spines........Pleustes, p. 488
OO. Abdomen devoid of tubercles or spines, except at the postero-dorsal and postero-lateral angles........Paramphithoë, p. 489
NN. Body without a prominent dorsal carina.
O. Antennæ with calceoli; last peduncular joint of the first antennæ with a terminal lobe.
Dorsal spines on some of the body segments........Haliragres, p. 495
No dorsal spines........Calliopius, p. 494
OO. Antennæ without calceoli; no terminal lobe on the last peduncular joint of the first antennæ.
First antennæ longer than the second........Sympleustes, p. 490
First antennæ shorter than the second........Apherusa, p. 495
GGG. Terminal uropods biramous, inner ramus minute. Last three segments of the abdomen fused.
Uropods remarkably modified........Chelura, p. 508
CC. First two pairs of peræopods with spinning glands.
D. Terminal uropods uniramous.
E. Mandibular palp one-jointed........Siphonœcetes, p. 522
EE. Mandibular palp two jointed........Corophium, p. 521
EEE. Mandibular palp three-jointed
Last two pairs of uropods uniramous........Cerapus, p. 517
Penultimate pair of uropods biramous. Second gnathopods larger than the first........Erichthonius, p. 518
DD. Terminal uropods biramous.
E. Propodus of the second gnathopods not subchelate........Ptilocheirus, p. 522
EE. Propodus of the second gnathopods chelate or subchelate.
F. Terminal uropods with short hooked rami (Podoceridæ).
G. First antennæ with a secondary flagellum.
H. Hand of the second gnathopod of the male very large, and having a thumb-like process arising from near the base of the posterior side........Jassa, p. 511
HH. Second gnathopods of the male not as in Jassa.
Antennæ rather stout, densely setiferous posteriorly, flagella with few segments...Ischyrocerus, p. 513
Antennæ slender, with multiarticulate flagella........Grubia, p. 510
GG. First antennæ without secondary flagellum........Amphithoë, p. 509
FF. Terminal uropods with narrow rami devoid of terminal hooks.
G. Second gnathopods much larger than the first, first antennæ with no accessory flagellum..Podoceropsis, p. 524
GG. First gnathopods much larger than the second, first antennæ with a secondary flagellum.
Second gnathopods of the male complexly subchelate........Microdeutopus, p. 514
Second gnathopods of the male simply subchelate........Autonoë, p. 516

### **Talorchestia longicornis** (Say).

Eyes large; first antennæ but little exceeding the penultimate joint of peduncle of the second, flagellum about as long as preceding basal joint, and composed of about six segments; second antennæ long, in males sometimes as long as the body, last joint of peduncle armed with short spinules and longer than all preceding joints; flagellum longer than peduncle; epimera not so high as their segments, the lower margins short-setose; first gnathopods in male with the fifth joint produced at the infero-distal angle into a long, rounded lobe; sixth joint gently widening distally, the infero-distal angle produced and rounded; palm transverse; claw projecting much beyond the palm; second gnathopods in male with hand oblong, large, and thick; anterior margin evenly rounded, the posterior nearly straight; palm oblique, the posterior angle produced; middle part of palm with a broad, convex lobe; finger short, strongly curved at tip, closing on the inner side of a prominence at outer end of palm; in the female the first gnathopods resemble those of the male, but there is no prominent lobe on the fifth joint, and the sixth joint is not distally widened nor produced into a lobe at the infero-distal angle; second gnathopods weak, second joint much widened and strongly convex in front; hand oblong, the lower end rounded; dactyl minute and located on the margin some distance above end of hand; third pereopods very short, the second joint as wide as long; first uropods extending slightly beyond second, rami subequal and about equal to peduncle; in the second pair the rami are longer than the peduncle and the inner rami are considerably longer than the outer; ramus of last uropods about as long as peduncle, but much narrower; telson triangular, fleshy, emarginate at tip, and furnished with a median dorsal groove.



*Talorchestia longicornis.* Woods Hole, Mass. The gnathopods of the male are drawn to a smaller scale than those of the female.

General color whitish, with often a row of brown spots along the middle of the back. Antennæ reddish or pink at the base, flagella blue; propodi of the posterior peraeopods bluish.

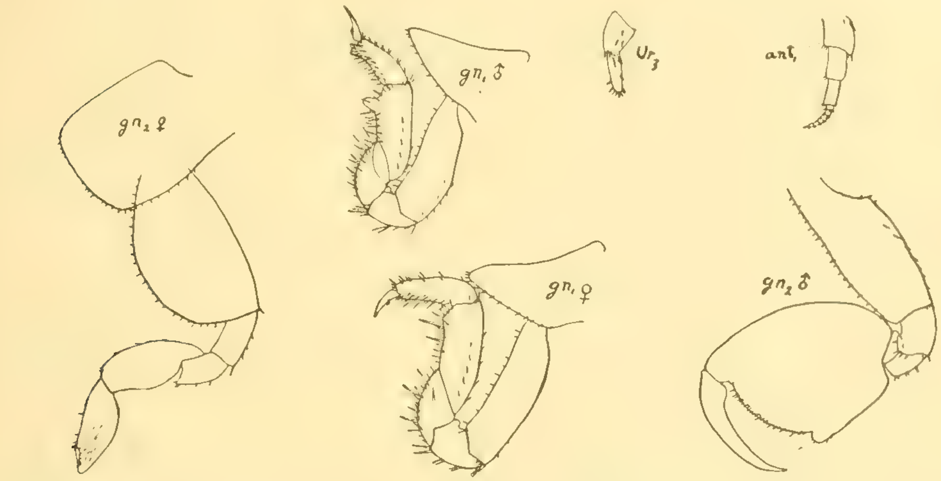
Length, 2 cm.

Cape Cod to New Jersey.

This species is commonly very abundant on sandy beaches. In the daytime these sand fleas lie quiet in their burrows, which are generally some distance above high tide mark. Their presence is indicated by small holes in the sand. The burrows are only a few inches deep, the depth depending largely upon how far the animal has to dig in order to reach moist sand. When dug out in the daytime *Talorchestia* is rather sluggish and apparently dazed. It often curls up and lies quiet as if feigning death and may even be picked up and handled in some cases without betraying signs of animation. When aroused it commonly makes a few leaps, when, especially if it alights upon loose sand, it lies quiet for a short time and than begins to burrow. At night it comes out of its burrows and may be seen in large numbers running over the seaweed recently washed ashore, which affords its principal food. Then it is very alert and is able to detect one's approach at a distance of several yards. It is strongly attracted to light and gathers around a lantern in swarms. In fact, the easiest way to procure large numbers of this species is to take a lantern into their midst at night, placing it in the middle of a large blanket or sheet. The *Talorchestia* that congregate about the lantern may then be gathered in quantity and preserved.

### **Talorchestia megalophthalma** (White).

Eyes very large, covering greater part of head; first antennæ with the three joints of peduncle of subequal length; flagellum much shorter than peduncle; second antennæ much as in *T. longicornis*, but shorter; first gnathopods in male much as in preceding species; fifth joint with a prominent inferior lobe; sixth joint narrowing somewhat from the base to within a short distance from the distal end, where it is widened into a rounded posterior lobe; second gnathopods of male with a large, more or less ovate hand, with anterior margin evenly convex and the much shorter posterior margin nearly straight; palm oblique, evenly convex, spinulose, with a prominence bearing a strong spine at the posterior end; first gnathopods of female with no prominent inferior lobe and the sixth joint tapering distally and not produced at lower end; second gnathopods of female closely resembling those of *T. longicornis;* second abdominal segment produced into a small, acute, triangular process at infero-distal angle; first uropods with rami equal and about equal to peduncle; second pair with rami longer than peduncle, inner ramus the longer; third pair with ramus slightly longer than peduncle.



*Talorchestia megalophthalma.* Woods Hole, Mass. The second gnathopods of the male are drawn to a smaller scale than the other parts.

Color whitish.

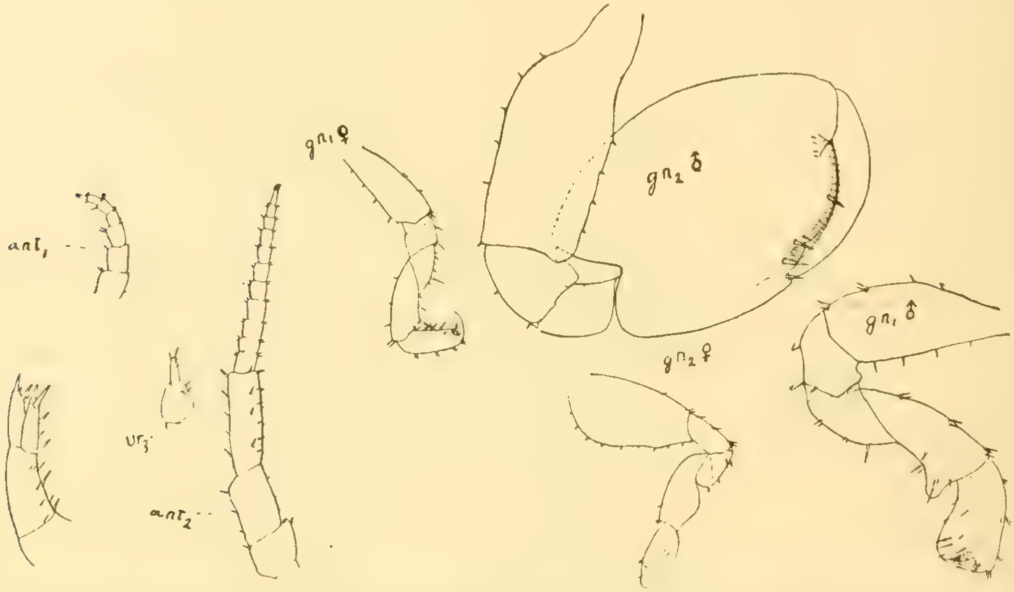
Length, 15 mm.

Casco Bay, Maine; Provincetown (Rathbun); Cape Cod to New Jersey.

This species is much less common than *longicornis*, but lives in similar situations. It is readily distinguished by its large eyes and the shape of the second gnathopods in the male. The specimen which was named *Orchestia megalophthalmus* by White and from which Bate drew his description came from an unknown locality. Owing to Bate's imperfect description and poor figure, it might be doubted whether the specimens referred to *megalophthalma* by Smith really belong to this species. Through the kindness of Mr. Bell, I have been able to compare specimens from Woods Hole, Mass., with the type specimen, which is preserved in the British Museum. Although the type is badly mutilated, I am convinced that the specimens from Woods Hole, which I brought for comparison, belong to the same species.

### **Orchestia agilis** Smith.

Eyes prominent; antennules scarcely reaching penultimate joint of peduncle of antenna; flagellum shorter than peduncle; antennæ scarcely half the length of body; peduncle stout in the male, last joint a little longer than preceding one; flagellum shorter than peduncle and composed of 10–15 short, compressed joints; first gnathopods of male with carpus produced below into a large, rounded lobe; propodus shorter than carpus, distally widened, the infero-posterior angle produced into a large rounded lobe, the distal margin forming a palm against which the finger closes; a deep notch between this lobe and base of finger; second gnathopods of male with propodus very large and stout; palm very oblique, convex, and notched a short distance within the posterior angle, which is a little produced; "the margin, when viewed laterally, shows a broad lobe next the base of the dactylus and two small, rounded lobes near the posterior angle, the tip of the finger resting between the small lobes." In the female neither carpus nor propodus is furnished with a lobe, although the posterior margin of the former is somewhat produced below the middle; second gnathopods of female with propodus oblong, rounded below, and furnished on the anterior margin with a minute dactyl which does not reach the lower end; merus and carpus in posterior peræopods of adult male swollen; rami of first uropods markedly shorter than peduncle; those of second uropods subequal to peduncle; ramus of posterior uropods several times narrower than the thick peduncle but nearly as long; telson narrowly rounded behind or more or less pointed, spinulous.



*Ocrhestia agilis.* The antennæ and uropode are drawn to a different scale from the other parts, and the gnathopods of the male are drawn to a larger scale than those of the female. Specimens from Woods Hole.

Length, 1 cm.

General color, olive brown; antennæ red or reddish brown; legs, coxal plates, and after portions of the body of a bluish color.

Bay of Fundy to New Jersey.

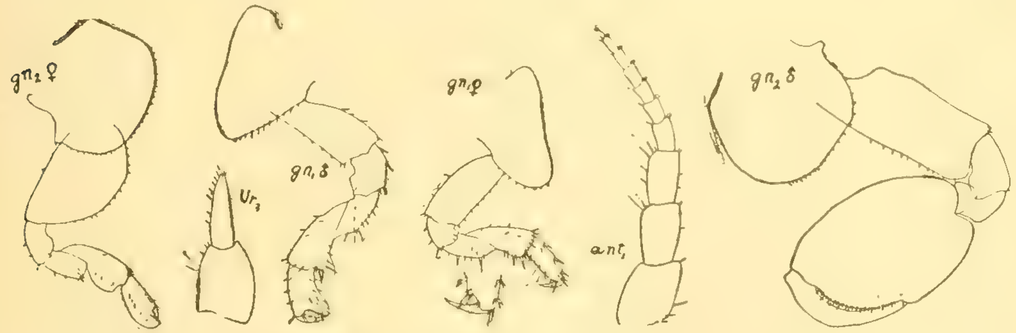
This species is exceedingly abundant under the masses of seaweed near the shore. It is seldom found so far up on the beach as *Talorchestia*, and is much more active during the daytime. Its specific name is very appropriate, as it hops with the greatest rapidity and, in relation to its size, to a remarkable distance. It is by far the most active of all the sand fleas of the region. When masses of seaweed are upturned the air sometimes fairly swarms with these amphipods. Like *Talorchestia* this species lives mainly upon seaweed, although it seems to be quite omnivorous and will not disdain animal food. It is seldom found under masses of drift that are not damp, or if so it is buried some distance in the sand. *O. agilis* will bear immersion for over a week in sea water, as I have determined by experiment, and is able to swim, when necessary, as if to the manner born. Occasionally I have found specimens on piles at a considerable distance from the shore—fortunate survivors, doubtless, of forms overtaken by the waves and carried out to sea. Like *Talorchestia longicornis* this species is strongly attracted to the light, although under certain conditions it may become negatively phototactic.

For details concerning the phototactic reactions of this and other species of amphipods, reference may be made to my paper on Phototaxis in the Amphipoda (American Journal of Physiology, vol. 5, p. 211).

This is undoubtedly the species referred to as *Orchestia gryllus* (Bosc), by Stimpson, and possibly also by De Kay and Say. Bosc's original description, however, does not enable one to decide whether he had specimens of this or some other species of *Orchestia*. His description and figure apply to *palustris* Smith, as well as to the above, although his statements that *gryllus* "se trouve en grande quantité," and that "elle saute par le moyen de sa queue et glisse sur la sable, par le même moyen, avec une rapidité dont on ne se fait pas une idée," would more naturally be made concerning *agilis* than *palustris*.

### **Orchestia palustris** Smith.

First antennæ reaching a little beyond tip of penultimate basal joint of second antennæ, the three basal joints of subequal length; flagellum nearly or quite as long as peduncle; second antennæ with penultimate basal joint two-thirds as long as the last one; flagellum longer than peduncle; second, third, and fourth epimera quadrate, rather broader than deep; first gnathopods of male much as in *agilis*, the carpus having a prominent rounded inferior lobe and the propodus distally widened and produced into a rounded lobe at the infero-posterior angle; second gnathopods of male with hand oval, palm very oblique and evenly convex and spinous, the posterior end defined by a small prominence within which the tip of the dactyl closes; otherwise the palm forms an even curve with the posterior margin of the hand; dactyl fitting closely to the palm. First gnathopods in female much as in *agilis*, carpus somewhat produced and rounded at the infero-posterior angle; second gnathopods of female also resembling those of *agilis*, but the second joint broader and much more strongly and evenly convex in front. Infero-posterior angles of second and third abdominal segments produced into triangular acute points; rami of first uropods shorter than peduncle, those of second pair subequal to the peduncle; ramus of last pair equalling or exceeding peduncle and relatively larger than in *agilis*; telson with a posterior notch, the lobes rounded, spinulous.



*Orchestia palustris.* Woods Hole. First antenna and third uropod drawn to a larger scale than the other parts.

Length, 18 mm.

Color olive brown to olive green; some individuals reddish brown; antennæ reddish brown.

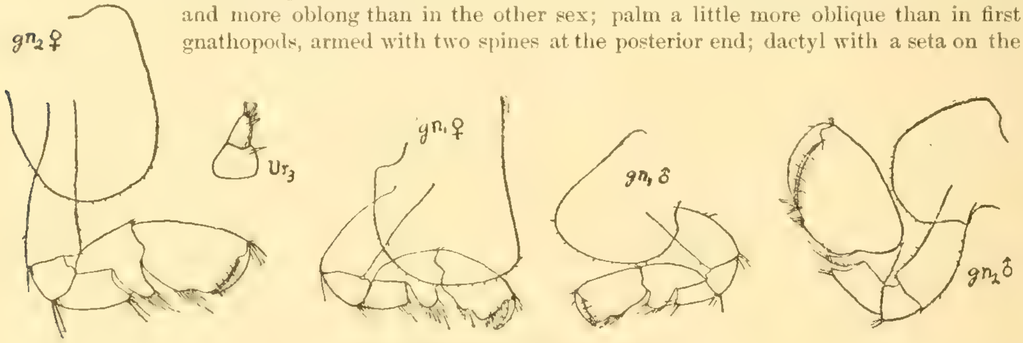
Cape Cod to New Jersey; coast of Texas.

This species is readily distinguished from *agilis* by its larger size, longer antennules, less robust hand on the second gnathopods of the male, the palm of which is not lobed, and the differently shaped second joint in the gnathopods of the female. Its habitat is also different, as it is found commonly around salt marshes, often far from the shore, among grass and weeds or under objects of various kinds which afford concealment. It crawls and runs more readily than *agilis* and is not so ready to hop.

### **Allorchestes littoralis** Stimpson.

*Hyale littoralis* Smith, Rept. U. S. Fish Com. 1871–72, p. 556.

Eyes oblong or reniform, their distance apart being less than their shortest diameter; first antennæ about three-fourths the length of second, the three joints of peduncle of subequal length; flagellum a little longer than peduncle and composed of 9–13 joints; second antennæ less than half the length of body; last joint of peduncle a little longer than preceding one, the lower side furnished with a large tuft of fine plumose hairs. First gnathopods much alike in the two sexes, third and fourth joints of subequal length, the latter produced distally into a prominent setose angle; fifth joint with posterior lobe oblong, rounded, and thickly setose; hand oblong, widening distally; palm slightly convex and nearly transverse, the posterior angle armed with two short but rather stout spines; posterior margin with a setose convexity a little distal to the middle; finger closely fitting the palm, inner margin with two or three short setæ; a single short seta on outer margin near base. Second gnathopods stout in the male; the second joint elongated and concave anteriorly, sparingly furnished with small spines on both margins; third joint about as wide as long; fourth joint about twice the length of preceding and strongly produced below into a pointed lobe; fifth joint with posterior lobe very long and narrow; hand large, roughly oval; palm oblique and evenly convex with two short, stout spines at its posterior extremity; posterior margin with a small setose convexity near the palm; finger much as in the first pair. In the female the second, third, and fourth joints of the second gnathopods resemble those of the male; posterior lobe of fifth joint not nearly so narrow and the hand smaller and more oblong than in the other sex; palm a little more oblique than in first gnathopods, armed with two spines at the posterior end; dactyl with a seta on the outer margin near the base as in the male. First and second uropods with rami subequal to peduncle; first pair with peduncle armed above with two rows of three or four spines each; last spine of inner row enormously developed, about two-thirds the length of rami and pointing backward; each ramus with two spines on upper margin and a cluster at the tip; peduncle of second uropods with a few spines above; rami with two spines on upper margin and a cluster at the pit; peduncle of third uropods very short and stout, with a single stout spine on the upper margin; ramus as long as peduncle but much narrower; the tip furnished with a cluster of spines. Telson deeply bilobed.



*Allorchestes littoralis.* Woods Hole, Mass.

Length, 6 mm.

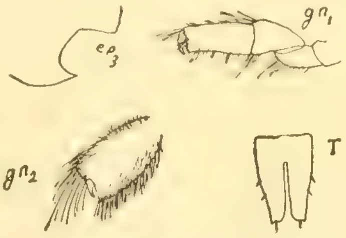
General color, green to olive brown; antennæ reddish brown; eyes black.

Grand Manan to Long Island Sound.

Found under rocks rather high up on the beach; in fact, this species shows an approach to a terrestrial habit, as it can with some difficulty walk upright while out of water and hops very readily like the species of the preceding genera.

### **Anonyx nugax** (Phipps).

Eyes large, dilated below, larger in the male than in the female; first antennæ in the female with secondary flagellum over half the length of primary one; second antennæ considerably longer than first; in the male both pairs of antennæ longer than in the female and the secondary flagellum of first pair not half the length of primary one; first gnathopods rather stout, hand long, subrectangular; palm transverse; hand of second gnathopods oblong-oval, about half as long as carpus, densely setose, the minute dactyl articulated near middle of distal margin; last two pairs of pereopods nearly equal in length and considerably longer than third; postero-lateral angles of third abdominal segment ending in a triangular acute projection, above which is a deep sinus; fourth abdominal segment with only a slight dorsal depression; terminal uropods with lanceolate rami furnished with marginal spines and setose on inner edges; inner ramus but little longer than basal portion of outer; telson oblong, cleft nearly to base, a small spinule at the tip of each lobe.



*Anonyx nugax.* After Sars. $ep_3$, Side of third abdominal segment. Second gnathopods enlarged.

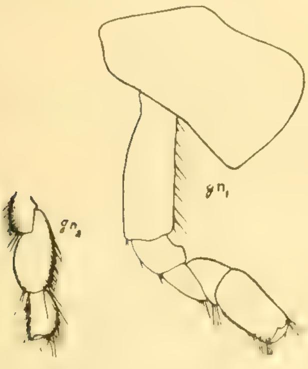
Arctic specimens may attain a length of 40 mm. (Sars). The New England representatives of this species are not often half that length.

Extensively distributed throughout the Arctic Ocean; found in the North Atlantic, Norway, Iceland, Greenland, Behring Sea, Labrador. Common off the coast of New England and often found in great abundance near Woods Hole.

### Tryphosa pinguis (Boeck).

*Anonyx pinguis* Boeck, Bemärken Norske Amphip., p. 662, 1860.
*Orchomenenella pinguis* Sars, Crust. Norway, p. 67, pl. 24, fig. 2, 1891.

A plump, firm, and compact species. Eyes elongated; antero-lateral corners of head produced and narrowly rounded; first antennæ short, first joint of flagellum elongated; second antennæ much longer than first, especially in the male; coxal plates very large, first four pairs more than twice as deep as their segments; fifth pair much deeper than wide, posterior part of lower margin produced into a rounded lobe; carpus of first gnathopods with a narrow posterior lobe; hand oblong, distally tapering; palm nearly transverse; hand of second gnathopods oblong, postero-distal angle produced; posterior peraeopods short, basal joints broadly suboval; postero-lateral angles of third abdominal segment rounded, the margin above the angle minutely crenulated or nearly smooth; fourth abdominal segment with a rather deep dorsal depression near anterior end; terminal uropods with inner ramus not exceeding basal portion of outer one; telson distally tapering and cleft to beyond the middle.



*Tryphosa pinguis.* Vineyard Sound.

Color, whitish.

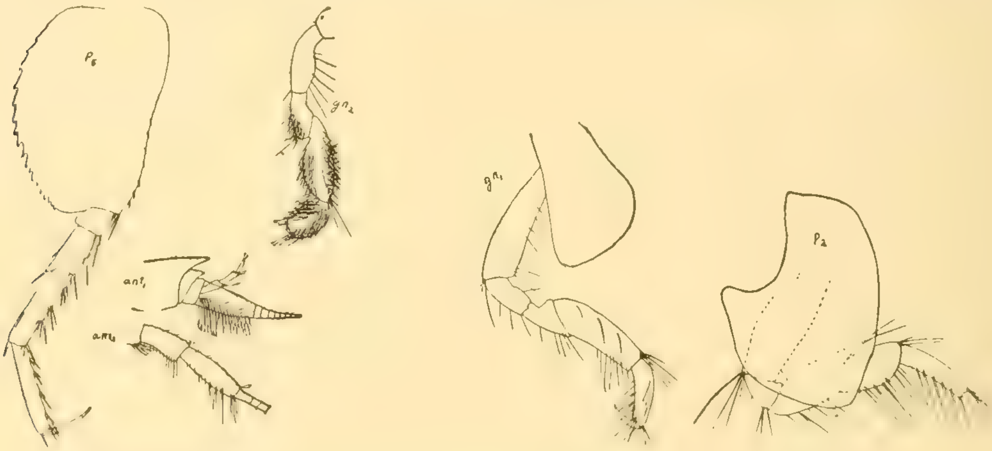
Length, about 7 mm.

Arctic regions; Norway; Greenland; Labrador; New England. Often taken in abundance near Woods Hole. It is not rarely found in company with *Anonyx nugax*.

This species is closely allied to *T. minuta*, but differs from it in having narrower eyes, stouter first gnathopods with a much narrower posterior carpal lobe, and in the crenulated posterior margins of the third abdominal segment. The forms from New England previously referred to *Orchomene minuta* doubtless belong to this species.

### Hippomedon serratus Holmes, new species.

Female: Eyes oblong, rather narrow; lateral lobes of head triangular, subacute; first basal joint of first antennæ produced distally into a lobe which reaches as far as tip of third joint; second joint distally produced into a much shorter lobe; first joint of flagellum as long as the eight remaining joints; lower margin fringed with long hairs; secondary flagellum three-jointed; second antennæ scarcely half the length of body, penultimate joint of peduncle about two-thirds length of terminal one; flagellum about twice the length of peduncle; first four coxal plates fully twice as deep as their segments, the first distally expanded, concealing the mouth parts; second and third coxal plates about three times as deep as wide, convex in front and concave behind; fourth pair markedly deeper than wide; first gnathopods with hand narrow, distally tapering, somewhat curved backward and about two-thirds length of carpus; palm pectinate with fine spines and not clearly defined above; dactyl about half length of palm; second gnathopods with hand longer than broad, densely ciliated and not exceeding half length of carpus; first and second peræopods with merus produced below nearly to middle of carpus; dactyl fully two-thirds length of narrow and somewhat incurved propodus; posterior margin of basal joint of last peræopods with large, acute serrations; serrations on basal joints of third and fourth peræopods very much smaller; dorsal margin of third abdominal segment quite suddenly deflected near posterior end; postero-lateral angles of this segment strongly produced and upturned much as in *H. propinquus* Sars.; fourth abdominal segment with a dorsal carina; last uropods projecting beyond first pair, rami about twice length of peduncle; telson cleft to beyond middle, the lobes pointed.



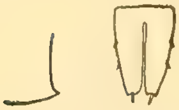
*Hippomedon serratus*, female. Newport, R. I. The second antennæ were broken in the specimen drawn.

In the male the first antennæ are a little longer and have more numerous joints than in the female, and the second antennæ are nearly as long as the body.

Length, 12 mm.

Newport, R. I. Off Cape Ann, 36 feet.

This species differs from *H. denticulatus* in the broader and much less abruptly upturned process at the postero-lateral angles of the third abdominal segment. From *H. propinquus* and *H. holbölli* it differs in having a larger lobe on the first basal joint of the first antennæ and in the form of the hand of the first gnathopods. In both these species the hand is widest near the middle and strongly convex behind; in our species the hand tapers from the base and is slightly concave behind. *Serratus* differs from all three of the species mentioned in having coarser serrations on the posterior margin of the basal joint of the last pair of peræopods.



*Hoplonyx cicada*. Angle of third abdominal segment and telson.

**Hoplonyx cicada** Fabricius.

Eyes narrow above, the lower part dilated; lateral corners of head rounded; first antennæ about as long as head and first two thoracic segments, secondary flagellum nearly as long as primary one and composed of about seven joints; second antennæ much longer than first; first four coxal plates more than twice as deep as their segments; fifth pair nearly as deep as wide; first gnathopods slender, the ischium twice as long as wide; propodus as long as carpus, scarcely tapering distally; palm oblique; second gnathopods with propodus oblong, about half as long as carpus; postero-lateral angles of third abdominal segment produced into a small tooth; fourth abdominal segment with only a slight dorsal depression; telson nearly twice as long as wide, tapering somewhat distally, and cleft nearly to the base, a minute spinule at tip of each lobe.

Length, about 15 mm.

Extensively distributed in the Arctic regions; Norway; British Isles; Iceland; Greenland; Labrador; New England. Often taken in considerable numbers near Woods Hole. Ranges from 20 to over 600 fathoms.

The eyes, which are pale in alcoholic specimens, contain in life a bright red pigment.

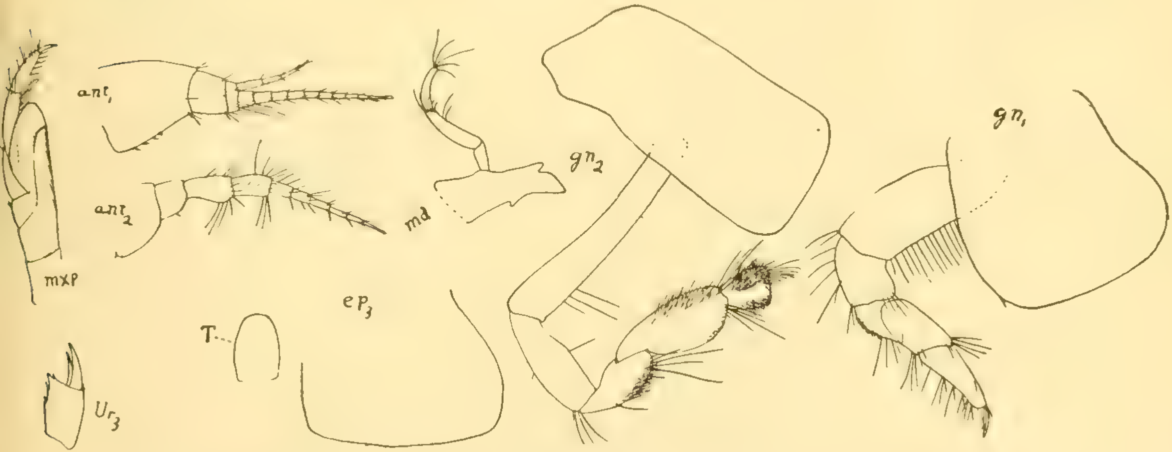
### LYSIANOPSIS Holmes, new genus.

Antennæ short and differing little in the two sexes; mandibles edentate, furnished with a three-jointed palp behind the middle, and a small molar process nearer the cutting edge than the base of palp; first maxillæ with narrow inner plate furnished with two apical setæ; palp two-jointed; maxillipeds with inner plate narrow and extending beyond middle of outer one; outer plate oval, the inner margin devoid of spines; palp narrow; anterior gnathopods rather stout, simple; second gnathopods slender; propodus short, setose, with a minute dactyl near middle of distal margin; postero-lateral angle of third abdominal segment rounded; uropods normal; telson entire.

This genus is closely allied to *Lysianella*, but differs from it in not having the penultimate joint of the second antennæ expanded, in having the first gnathopods simple instead of subchelate, and in having the outer ramus of the terminal uropods consisting of a single joint.

### Lysianopsis alba Holmes, new species.

Lateral corners of the head produced into a triangular subacute lobe; first antennæ short, first basal joint stout, longer than the next two; flagellum a little longer than the peduncle and composed of about ten joints; secondary flagellum about half length of primary one and composed of about four joints; second antennæ about as long as first; flagellum about as long as peduncle; mandibles each with a small molar tubercle; palp joined a little behind middle; first maxillæ with the inner plate narrow and furnished with two setæ at the apex; second maxillæ setose at the tip and ciliated on the inner margins. Inner plate of the maxillipeds furnished with plumose setæ on the inner margin and armed with a few short teeth at the tip; outer plate devoid of spines or setæ and serrated or crenulated on the inner margin; first gnathopods stout; propodus tapering distally to the rather stout dactyl; second gnathopods with the propodus subcordate; the three posterior peræopods increasing rapidly in length posteriorly, the last pair quite long and slender and having the posterior margin of the basal joint serrated; similar serrations on the two preceding pairs, but less pronounced; fourth abdominal segment slightly indented on dorsal side; first uropods extending backward farther than second, and these exceeding the third; peduncle of terminal uropods very stout, longer than the styliform rami and produced into a triangular projection at distal end of upper margin; telson oblong, entire, distally rounded.



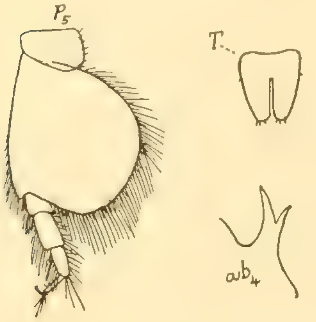
*Lysianopsis alba.* Eel Pond, Woods Hole, Mass. $ep_3$, Side plate of third abdominal segment.

Color white; eyes black. The yellow or orange gonads may often be seen through the integument. Sometimes specimens are of a yellowish color.

Length, 6 mm. Type No. 29246, U. S. Nat. Mus.

Found commonly in the mud in the Eel Pond at Woods Hole. Specimens were also taken off Nobska.

This species has the habit of lying very quiet for a long time with its body strongly flexed. When disturbed it starts quickly and swims vigorously for a time and then comes to a very sudden stop with its body flexed and lies quiet as before. Unlike most amphipods it is little affected by light, but contact with a solid body causes it quickly to stop when swimming and lie still. It has a strong propensity to get under any object it meets. Individuals coming in contact often try to get under each other.



*Pontoporeia femorata.* After Sars. $ab_4$, Dorsal side of fourth abdominal segment.

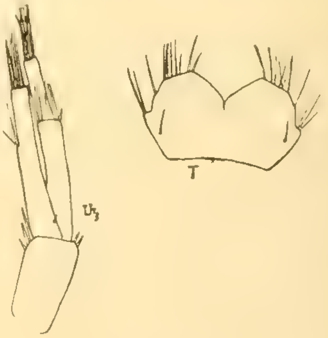
### Pontoporeia femorata Kröyer.

Eyes reniform, red in life; first antennæ about as long as the second; first peduncular joint a little longer than the next two; flagellum shorter than peduncle; secondary flagellum minute, two-jointed; flagellum of second antennæ a little shorter than peduncle; first four coxal plates of nearly equal depth, setose below, a small tooth on the postero-inferior angle of the first three; carpus of first gnathopods very broad, projecting in front of propodus, and furnished with a broad, setose lobe behind; propodus broadly subovate, the posterior margin bulging outward near the base; second gnathopods with propodus narrow, a little shorter than carpus; postero-inferior angle produced so that the hand is almost chelate; last pair of peræopods with basal joint very broad, rounded and strongly setose behind and longer than rest of appendage; fourth abdominal segment with a prominent bifurcated spinous projection in mid-dorsal line; telson somewhat longer than broad and cleft to beyond the middle.

Length, 14 mm.

Circumpolar; Norway (Sars); Greenland; Labrador.

I have found several specimens of this species in the collection of the Boston Society of Natural History, but they had no label giving their locality. It is probable that, like most of the other specimens in the collection, they came from somewhere on the New England coast.



*Haustorius arenarius.* Off Marthas Vineyard.

### Haustorius arenarius (Slabber).

*Lepidactylus dityscus* Say, Jour. Acad. Nat. Sci. Phila., Vol. I, 1818, p. 380.

Head with a short, triangular rostrum; eyes small, nearly round; both pairs of antennæ short; peduncle of first pair with numerous plumose setæ; secondary flagellum over half as long as primary; last two joints of peduncle of second antennæ compressed and much dilated, the lower margins fringed with long, plumose setæ; penultimate joint several times larger than the last one and produced into a rounded lobe at antero-inferior angle; flagellum not exceeding peduncle; first four coxal plates increasing successively in size, the first three concave behind, strongly convex in front and tapering below to a rather obtuse point; fourth coxal plate larger than the others, concave behind, strongly convex in front and broadly rounded below; gnathopods rather small, carpus widened at middle, larger than propodus, which is very thickly setose and bears a small terminal dactyl which is much reduced in the second gnathopods; first two pairs of peræopods similar, carpus much dilated, being produced into a very large, rounded posterior lobe, which is furnished on the margin with several spines; propodus more or less pyriform, flattened, constricted toward the base, the rounded extremity armed with several spines; third peræopods with basal joint, merus and carpus much dilated, propodus narrow; fourth peræopods much larger than third, with the same joints dilated, the small and narrow propodus joined to posterior angle of the quadrate carpus; fifth peræopods large, the basal joint much enlarged, wider than long, merus short, produced posteriorly into a large lobe which is over twice as wide as long; carpus much dilated; propodus much larger than in the preceding pairs. The three posterior segments of the abdomen small. First uropods with a very stout peduncle, which is bent upward, the upper margin armed with several stout spines and concave except near the base, where there is a prominence surmounted by an unusually stout spine, the first of the series, in front of which (proximally) are several long setæ; rami narrow, unequal; terminal uropods with rami about twice length of peduncle, inner ramus the larger and two-jointed; telson broad, divided into two lobes, which are setose on outer and distal margins.

Length, 18 mm.

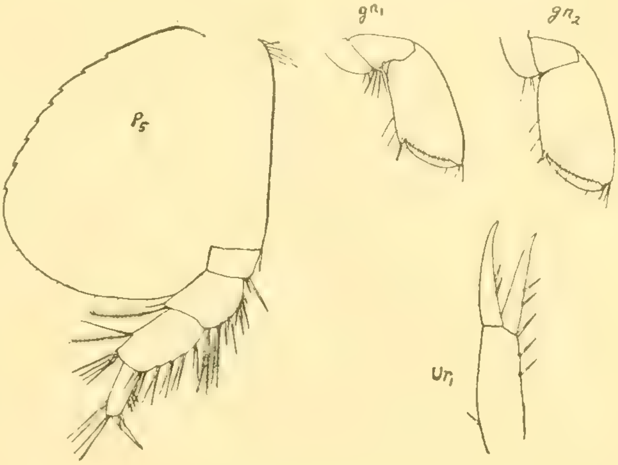
Georgia to Cape Cod (Smith); off Marthas Vineyard; Holland (Slabber); Norway (Boeck); France; British Isles.

I have examined specimens from North Devon, England, and have satisfied myself of their specific identity with our American forms.

### **Phoxocephalus hölbölli** (Kröyer).

*Phoxus kröyeri* Stimpson, Marine Invert. Grand Manan, p. 53, 1853.

Head with the rostral broad triangular, about equaling peduncle of first antennæ; eyes small and imperfectly developed; first antennæ shorter than second and not as long as head, first joint of peduncle thick, about as long as next two and having a triangular process at distal end; flagellum six-jointed and nearly as long as peduncle; secondary flagellum three-jointed and a little over half length of primary one; second antennæ with penultimate joint expanded, furnished with several spines on surface and distal end and several long setæ on lower margin; flagellum six-jointed and shorter than peduncle; first four coxal plates deeper than wide and much deeper than their segments, lower margins setose; first gnathopods nearly as large as second; basal joint curved forward; hands of both pairs of gnathopods oblong, slightly widened distally, the palm oblique, evenly convex, and terminated distally with a triangular tooth, at the side of which is inserted a strong spine; first and second peræopods with merus much wider than carpus and nearly twice as long; propodus narrow, of about same width throughout; dactyl about one-fourth length of propodus; third peræopods with basal joint very broad and about two-thirds as long as rest of appendage; last peræopods with basal joint very large, serrated posteriorly and fully as long as all the other joints; postero-lateral angles of third abdominal segment narrowly rounded; terminal uropods with rami subequal in the male, narrowly lanceolate and furnished with plumose setæ; in the female inner ramus devoid of setæ and much shorter than the outer; telson cleft nearly to base into two narrow lobes.



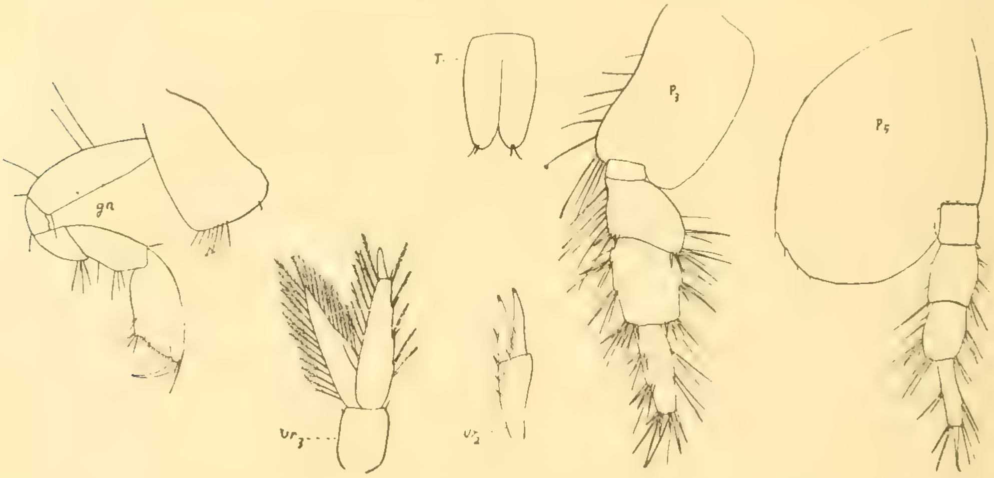
*Phoxocephalus hölbölli*, female. Grand Manan.

Length, 5 mm.

Arctic regions; Norway; British Isles; France; Iceland; Greenland; Labrador; Grand Manan (Stimpson); Vineyard Sound in deep water (Smith).

### **Paraphoxus spinosus** Holmes, new species.

Male: Rostrum projecting beyond the first basal joint of first antennæ; eyes very large; second antennæ with slender flagellum over half length of body; first four coxal plates increasing successively in length and furnished below with several simple setæ; first pair expanded distally· first and second gnathopods very nearly alike; hand oblong, slightly widened distally with an oblique, gently convex palm which terminates posteriorly in a rounded elevation furnished with a few slender spines; first and second peræopods with carpus scarcely half as long as merus and about two-thirds the length of the very narrow propodus; dactyl nearly straight and over half length of propodus; third peræopods with basal joint oblong, slightly concave in front and slightly convex behind; merus a little wider than long; carpus quadrate, broadly expanded, armed with stout spines; propodus much narrower than carpus, but about as long, armed in front with three fascicles of stout spines; dactyl slender, over half length of propodus; fourth peræopods stouter than in *oculatus;* carpus shorter than merus or propodus, and, like those joints, armed with fascicles of strong spines; dactyl styliform; fifth peræopods with basal joint expanded much as in *oculatus;* merus slightly longer than carpus; dactyl slender, the tip turned slightly forward; posterior margin of lateral expansions of third abdominal segment furnished with several setæ; first uropods with rami nearly as long as peduncle, the inner ramus with usually a single spine near middle and the outer with two or three spines on the basal half of upper margin; second uropods reaching about to middle of rami of first pair; third uropods extending far beyond the first; rami furnished with plumose setæ on both margins, outer ramus with a few short spines on outer side; telson longer than broad, the lobes distally rounded.



*Paraphoxus spinosus*, male. Newport, R. I.

Type No. 29241, U. S. Nat. Mus.

Length, 4.5 mm. Newport, R. I., taken by S. D. Judd.

Numerous specimens were examined, but they were apparently all males and unfortunately the terminal joints of the first antennæ had in all cases been broken off. In the type species of *Paraphoxus* (*P. oculatus*) the two pairs of antennæ in the female are of nearly equal length, the eyes of the female are very much smaller than those of the male, and the terminal uropods smaller, much more unequal in size, and devoid of the marginal plumose setæ found in the male. It is probable that similar sexual differences will be found to occur in the present species.

This species may be distinguished from *oculatus* by its stouter appendages. In the third peræopods the merus is relatively shorter and broader and the carpus broader than in *oculatus;* the joints of the fourth peræopods are much stouter and armed with strong spines. In *oculatus*, according to Sars's figure in the Crustacea of Norway, there are no setæ on the posterior margin of the lateral expansions of the third abdominal segment.

### **Harpinia plumosa** (Kröyer).

*Phoxus fusiformis* Stimpson, Marine Invert. Grand Manan, p. 57, 1853.

Rostral hood extending beyond the antennular peduncle, eyes wanting; first antennæ nearly as long as head, first basal joint larger than the next two and bearing a few large plumose setæ at distal end of lower margin; second joint produced somewhat at distal end of lower side, where it bears several large, plumose setæ; flagellum shorter than peduncle and composed of about six joints; secondary flagellum over half the length of primary one and composed of about five joints; second antennæ slightly longer than first, the penultimate basal joint broadly expanded and rounded below, where it bears about seven large, plumose setæ and several curved spines; flagellum shorter than peduncle and composed of 5–7 joints; first four coxal plates much deeper than their segments and fringed below with long, plumose setæ; first and second gnathopods of nearly equal size; hands oval; palm oblique and defined posteriorly by a prominence; posterior peræopods with the widely expanded basal joint produced and rounded below, and coarsely dentate on the posterior margin with a few irregular and sometimes obscure teeth; postero-lateral angle of third abdominal segment produced into a slender, slightly upturned spine; telson about as broad as long, the lobes distally rounded.

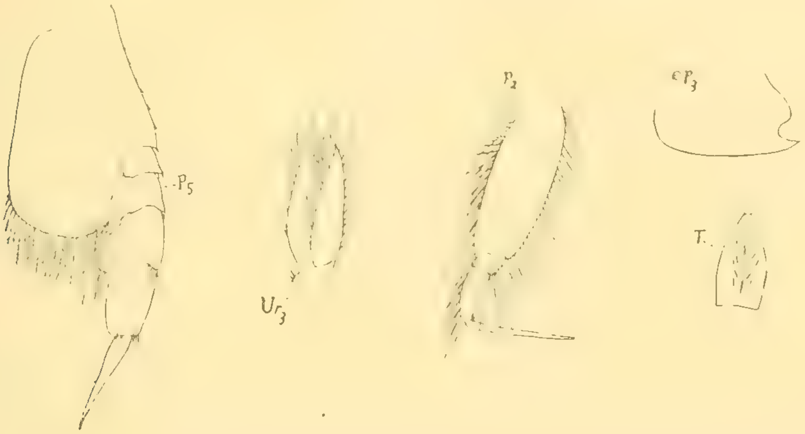
Length, 7 mm.

Arctic regions; Norway; Greenland; Grand Manan; *Albatross* station 2212.

### **Ampelisca macrocephala** Lilljeborg.

*Pseudophthalmus pelagicus* Stimpson, Marine Invert. Grand Manan, p. 57, 1853.
*Ampelisca* sp. Smith, Rept. U. S. Fish Com. 1871–2, p. 561, pl. IV, fig. 17.

Head about as long as first three segments of thorax; eyes surrounded with bright-red pigment: lower corneal lens at antero-lateral angle of head; first antennæ in the female often shorter than peduncle of second pair; second antennæ of the female scarcely exceeding half the length of body, last segment of peduncle shorter than preceding one; first pair of coxal plates distally widened and extending as far forward as the eyes; propodus of first gnathopods oblong, about as long as carpus; that of second gnathopods about half as long as carpus; dactyl of first and second peræopods considerably larger than the two preceding joints combined; last peræopods with basal joint broadly rounded below; ischium broader than long; merus deeply concave below, and produced into a pointed setose lobe at the lower posterior angle; carpus more or less heart-shaped; lower posterior angle more produced than corresponding anterior one and armed with several spines; propodus oblong; lower posterior angle rounded and slightly produced; dactyl slender, often a little longer than propodus; postero-lateral angle of third abdominal segment with a long, acute, slightly upturned projection, above which is a rounded sinus followed by a rounded lobe; fourth abdominal segment in the female with a slight dorsal depression followed by a carina, which ends abruptly at the posterior end; penultimate uropods with outer ramus armed near tip with a very long spine.



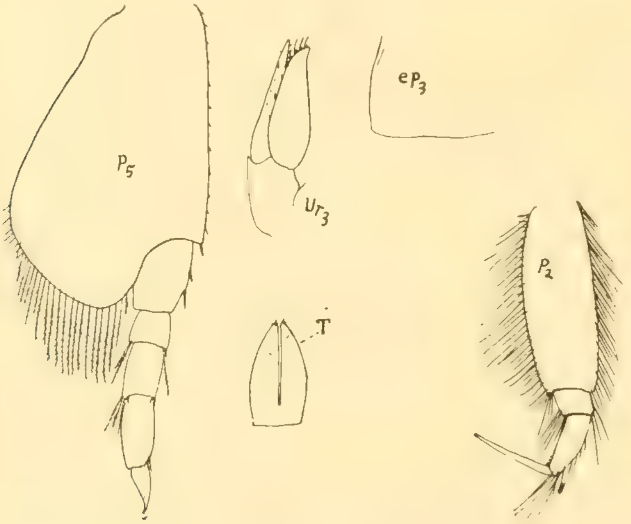
*Ampelisca macrocephala*, female. Woods Hole, Mass. *cp*3, Side plate of third abdominal segment.

Length, 15 mm.

Woods Hole; Newport; Spanish Bay; Cape Ann; Casco Bay, Maine; off Halifax; Grand Manan. Specimens taken from near Woods Hole differ from those figured in Sars's Crustacea of Norway in that the first pair of coxal plates project a little farther forward, the dactyl of the last pair of peræopods is as long as, or a little longer than, the propodus, and the dactyls of the first and second peræopods are a little larger. At first I was inclined to regard the Woods Hole forms as constituting a species distinct from, but very closely allied to *macrocephala*, but a comparison of them with specimens taken at various places along the coast farther north led me to consider them as not specifically distinct. The specimens from north of Cape Cod present gradations between those found at Woods Hole and the forms figured by Sars, so that none of the differences enumerated are constant.

### **Ampelisca spinipes** Boeck.

First antennæ of female a little longer than peduncle of second pair; second antennæ less than half the length of body; last two joints of peduncle of subequal length. First antennæ in the male very much longer than in the female, being over one-third the length of body; second pair exceeding length of body and with last joint of peduncle much longer than preceding one; propodus of first gnathopods nearly as long as carpus and somewhat bulging on proximal portion of posterior margin; second gnathopods slender, the narrow carpus nearly twice as long as the propodus; dactyl of first and second peræopods about as long as two preceding joints combined; last pair of peræopods with ischium nearly twice as long as wide, much longer than the nearly square merus; carpus subrectangular, elongated; propodus longer than carpus or dactyl; postero-lateral angle of third abdominal segment not produced, and forming nearly a right angle; fourth abdominal segment of the male with a prominent dorsal carina which ends abruptly posteriorly; the following segment deeply indented above; the corresponding features of the female are much less pronounced; no long terminal spine on outer ramus of penultimate uropods; terminal uropods thickly setose in the male but nearly devoid of setæ in the female.



*Ampelisca spinipes*, female. Near Woods Hole, Mass. $ep_3$, Side plate of third abdominal segment.

General color, whitish; a rose-colored or light-purplish spot in the first coxal plate; a few other spots of the same color may occur on other parts of the body.

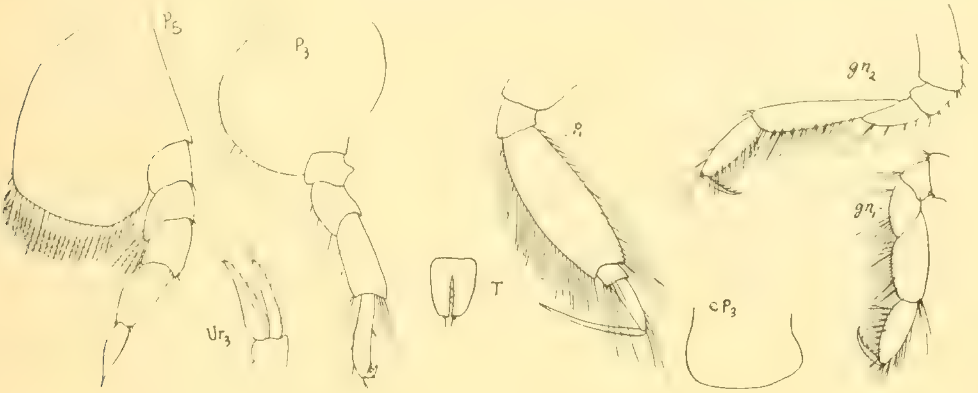
Length, 14 mm.

Woods Hole; Long Island Sound; Newport; Norway (Sars); France.

The male differs from the female in having longer second antennæ, with the terminal joint of the peduncle relatively longer, the last basal joint being only a little longer than the preceding one in the female; in having the lower side of the peduncle of the first antennæ and the upper side of the peduncle of the second furnished with numerous tufts of short setæ; in having the fourth abdominal segment with a deeper depression on the proximal portion of the upper side and a more prominent dorsal carina, and in having the terminal uropods more strongly ciliated.

### **Ampelisca compressa** Holmes, new species.

Body strongly compressed and generally strongly flexed; head markedly shorter than first three segments of thorax; first antennæ shorter than peduncle of second pair; third joint of peduncle a little shorter than first; flagellum only a little longer than peduncle, second antennæ slender, over half length of body in female, and much longer than body in adult male; peduncle in male over a third length of body, last joint a little shorter than preceding one; first four coxal plates higher than their segments, the first considerably expanded below; first and second peræopods with dactyl slender and longer than two preceding joints. Posterior peræopods with basal joint widely expanded; ischium as broad as long; merus with a posterior lobe extending to middle of carpus. Postero-lateral angle of third abdominal segment broadly rounded; fourth abdominal segment in both sexes with a prominent dorsal crest which increases in height posteriorly and carries a pair of short setæ on its posterior margin; terminal uropods similar in two sexes, furnished with only a few short spinules and setæ; outer ramus of nearly same width throughout its length; telson about two-thirds as wide as long, lobes rather obtuse distally, but with inner angles subacute.



*Ampelisca compressa.* Vineyard Sound. *cp*$_3$, Side plate of third abdominal segment.

Length, 6 mm.

Vineyard Sound; Newport; off Block Island; Long Island Sound.

This is the most common species of *Ampelisca* in the regions around Woods Hole. It is apparently easily obtained in large quantities, as I have examined several bottles containing thousands of specimens of this species with scarcely any other amphipods.

### Ampelisca agassizi Judd.

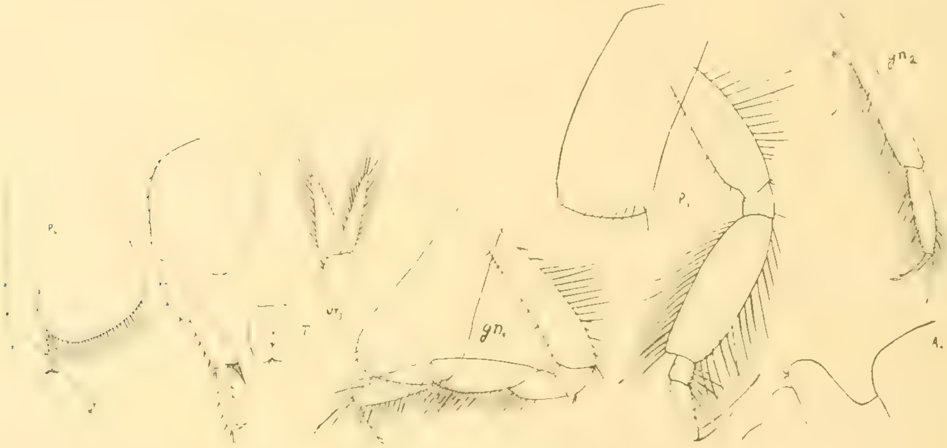
*Byblis agassizi* Judd, Proc. U. S. Nat. Mus., Vol. XVIII, 1895, p. 599, figs. 9, 10a–f, 11a–c.

Male: Head about as long as first three segments of thorax; eyes normal; first antennæ scarcely half length of body; the first joint of peduncle scarcely twice as long as thick, the second nearly twice as long as first and about three times length of third; first two or three joints of flagellum with rather long setæ on lower side, the remaining segments narrow, elongated, and furnished with very short setæ; lower sides of first two joints of peduncle furnished with tufts of very short hairs; second antennæ exceeding length of body; antepenultimate and penultimate joints of peduncle with tufts of short hairs above; last peduncular joint about as long as preceding one; first gnathopods with distal end of coxal joint widened, and about two-thirds as long as carpus; dactyl of first and second gnathopods about as long as two preceding joints; last peræopods with basal joint broad and produced below nearly to tip of merus, lower margin rounded; merus produced distally on posterior side as far as middle of carpus; propodus fusiform, longer than carpus; postero-lateral angle of third abdominal segment rounded; fourth abdominal segment constricted at base, the posterior portion furnished with a high rounded median dorsal crest, the following abdominal segment with a dorsal indentation; terminal uropods extending beyond the others by about half the length of their rami, the rami setose on both margins and not serrated; telson longer than wide, cleft nearly to base, sides convex and lobes distally rounded, each furnished with a pair of short setæ.

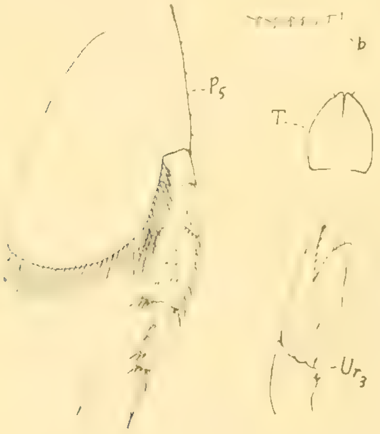
Length, about 7 mm.

Described from Mr. Judd's type specimens (No. 18919) obtained from the U. S. National Museum.

This species is, in some respects, intermediate between *Byblis* and *Ampelisca*, but its affinities are mainly, I believe, with the latter genus. The form of the mandibular palp is like that of the type species of *Byblis*, but the broad second joint of this appendage, which is said to characterize *Ampelisca*, is not a generic character of much importance. In *Ampelisca spinipes*, for example, this joint is only slightly widened, although it is broader than in *Byblis*. *A. agassizi* agrees with *Ampelisca* and differs from *Byblis* in that the telson is much longer than broad and cleft nearly to the base, in the form of the last pair of peræopods, and in the fact that the terminal uropods project much beyond the preceding ones and have no serrations on the opposing margins of the rami.



*Ampelisca agassizi.* *A*, dorsal margin of the 3d, 4th, and 5th segments of the abdomen. Drawings made from one of Mr. Judd's type specimens.



*Byblis serrata.* Woods Hole, Mass. *b*, Lower margin of first coxal plate in the male.

### Byblis serrata Smith.

Body and appendages furnished with scattered pigment cells; first antennæ much longer than peduncle of second; second antennæ shorter than body in the female, but longer than body in the male, last joint of peduncle a little shorter than preceding one; lower margins of anterior pairs of coxal plates serrated, the serrations prominent and acute in the female but blunt in the male; dactyls of first two peræopods about as long as the propodi; posterior lobe of basal joint of last pair of peræopods reaching about to tip of carpus; postero-lateral angle of third abdominal segment rounded; fourth abdominal segment in male with a dorsal depression, behind which is a prominent, rounded carina; these features much less pronounced in the female; first and third uropods extending backward to about the same distance, second pair not reaching so far; telson pointed, cleft to the middle.

Length, 11 mm.

Woods Hole; Newport.

A description of the sexual differences in this species is given by Judd (Proc. U. S. Nat. Mus., Vol. XVIII, p. 596, 1896).

### Stegocephalus inflatus Kröyer.

A large species, easily recognizable from its tumid form and enormous coxal plates. Head partly concealed and pointing downward, with a flattened, triangular rostrum and a prominent, subacute process between bases of antennæ; antennæ short, of nearly equal length; first pair very stout, with first joint of peduncle somewhat longer than both the other two, third joint much wider than long; flagellum thick and tapering, secondary flagellum minute; peduncle of second antennæ much more slender than that of first and a little longer than the flagellum; thorax tumid, first five coxal plates taken together forming an almost semicircular plate; the second, third, and fourth much deeper than their segments; first and second gnathopods small, similar, subchelate hands narrow; basal joint of last peræopods much enlarged, postero-inferior angle acute or subacute; fourth abdominal segment with a dorsal depression; telson acute, with a narrow posterior incision extending beyond the middle.

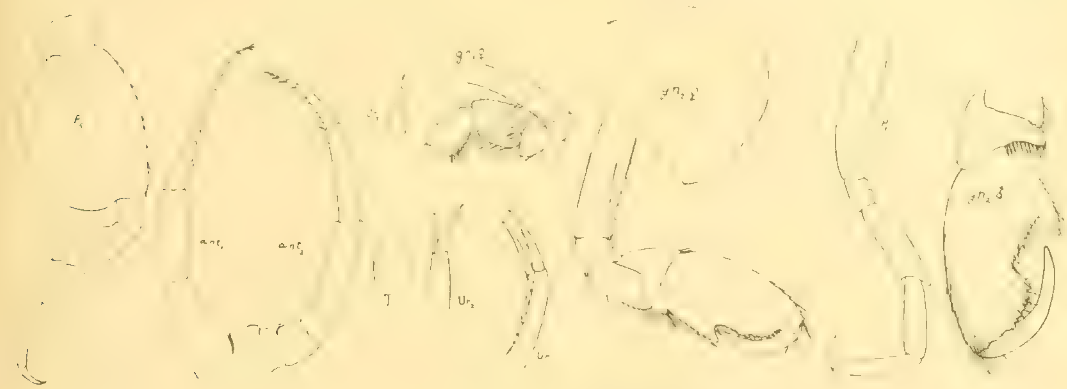
This species is said by Hansen to attain a length of 47 mm.

Extensively distributed in the Arctic and North Atlantic oceans. I have examined specimens taken at Grand Manan (100 fathoms); Eastport; off Head Harbor, Me. (100 fathoms); and near Woods Hole.

### **Metopa grœnlandica** Hansen.

*Stenothoë clypeata* Stimpson, Marine Invert. Grand Manan, p. 51, 1853.

Female: Eyes nearly round; antennæ of nearly equal length; peduncle of first with first two joints of subequal length, third joint about a third the length of second; flagellum shorter than peduncle and composed of about nine joints; peduncle of second antennæ much longer than that of first, last joint a little shorter than preceding one but somewhat longer than the flagellum, which consists of about six joints, of which the first is much the longest; second, third, and fourth coxal plates very large and of subequal depth, second produced forward as far as eyes and broadly rounded in front; fourth coxal plate longer than deep, subquadrate with rounded angles, and about equal in length to three segments of thorax; mandibles with first joint of palp short, second expanded, a little over twice as long as wide, the inner margin setose; third joint small, scarcely a third the length of second and not half so wide; maxillipeds with inner plates distally rounded and nearly reaching extremity of the following joint, which is slightly produced at inner distal angle into a rudimentary outer plate; palp large, first three joints of nearly equal size; fourth joint in the form of a large incurved claw; first gnathopods small, basal joint narrow, carpus large, longer and broader than hand and setose on surface and both margins; hand narrowed toward base, palm transverse; second gnathopods with carpus produced into a narrow, posterior lobe; hand large, oblong, palm convex and dentate, ending above in a sinus which lies just within the base of a large tooth; first two peræopods slender, devoid of spines; last two peræopods with basal joints much dilated, especially in last pair; first uropods with rami shorter than peduncle; second pair with longer ramus nearly equal to peduncle; single ramus of terminal uropods about equal to peduncle, and pointed apical division of ramus nearly as long as basal part; telson oblong, the extremity narrowly rounded.



*Metopa grœnlandica.* Eastport, Me.

The color is described by Stimpson as "bright yellow; in the young pale bluish. Eyes conspicuous, red."

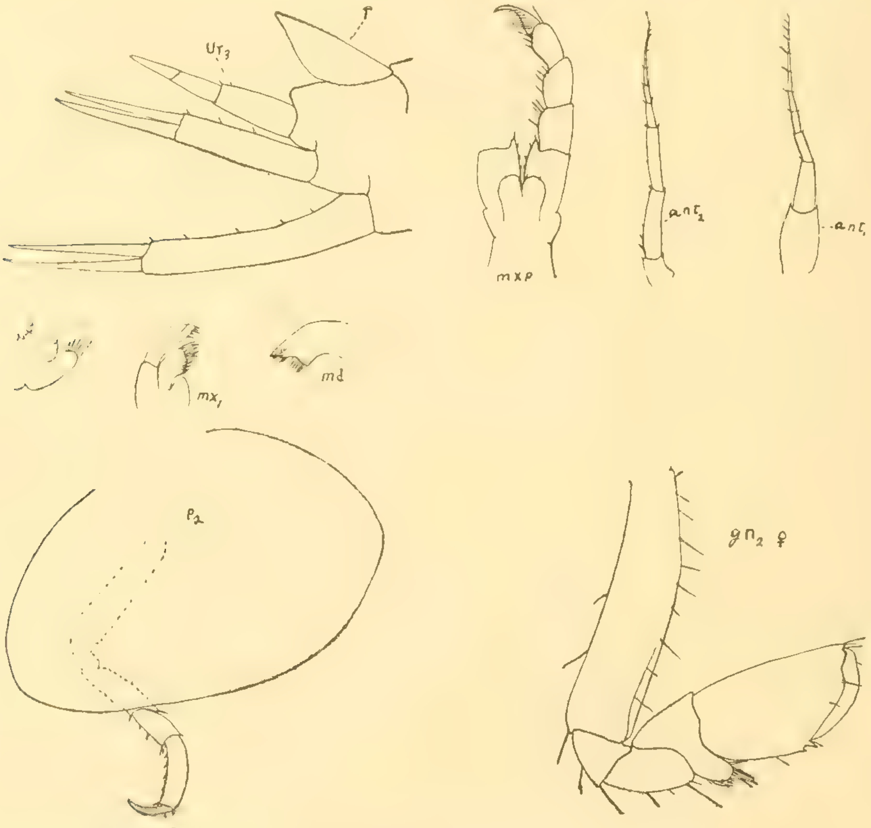
Length, 7 mm.

Grand Manan (Stimpson); Eastport, Me.; *Albatross* stations 2057 and 2062; Greenland (Hansen).

In the male of this species the second joint of the first antennæ is relatively somewhat longer than in the female; the second gnathopods are stouter, the ischium has a prominent anterior lobe, the hand is oblong with a large pointed process above the middle, the proximal portion of the palm is nearly straight and dentate, with a deep sinus between it and the pointed process.

### **Stenothoë cypris** Holmes, new species.

Eyes round; antennæ of subequal length and about one-third the length of body; peduncle of first pair with first joint very stout and nearly as long as the next two; third joint a little over half as long as second; flagellum subequal to peduncle and composed of six to eight joints; peduncle of second antennæ more slender and much longer than that of first, the last two joints of subequal length; flagellum shorter than peduncle and composed of about six joints. No mandibular palp; inner plate of first maxillæ small, outer armed with five mostly pectinated spines on distal margin and having numerous short setæ on inner side; palp one-jointed, incurved, with about five spines at distal end; outer plate of second maxillæ much longer than inner and furnished with six setæ on rounded distal margin; inner plate of maxillipeds very small and rounded; outer plate represented by a small process on inner angle of ischium; first gnathopods simple; propodus tapering distally; coxal plate well developed; second gnathopods larger than first; coxal plate fairly large; basal joint bent forward and armed with several slender spines on anterior margin and a very few on posterior one; carpus produced behind into a long, distally rounded lobe, which bears a few very stout pectinate setæ; hand oblong, widest near distal end; palm oblique with a stout spine near its distal end; coxal plate of first peræopods small, that of second enormous, broader than deep, more or less ovate in outline, and equal in length to about six segments of body; first uropods with peduncle longer than the subequal



*Stenothoë cypris.* The antennæ and peræopods are drawn to a different scale from the other parts. Woods Hole, Mass.

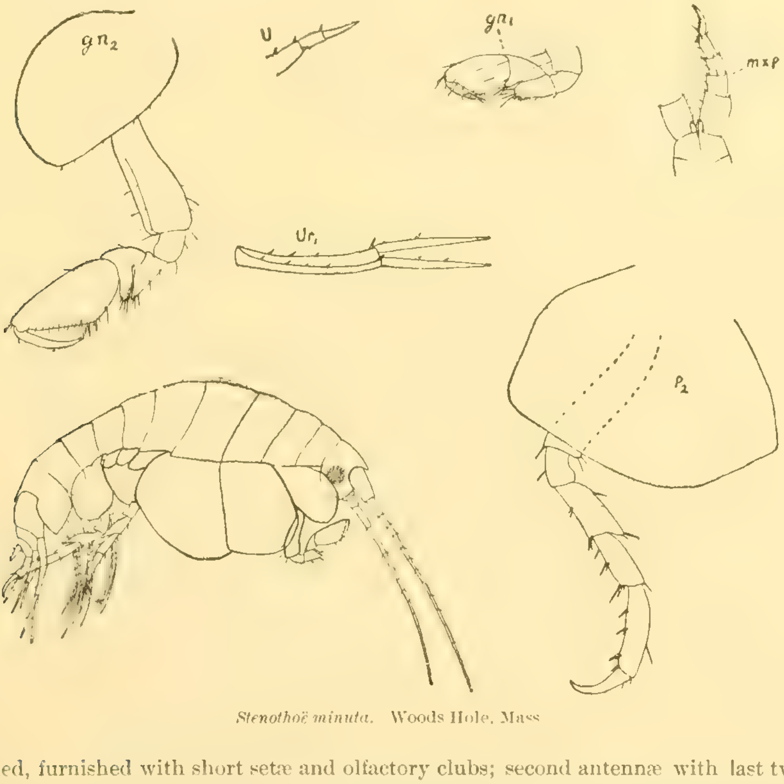
lanceolate rami; rami of second uropods nearly as long as peduncle; the single ramus of terminal uropods about equal or a little exceeding peduncle, and with terminal and basal segments of subequal length; telson entire, acute; in the male the palm of the hand of second gnathopods somewhat more oblique than in the female and furnished with several spines. Body pellucid; first segment more or less rose colored above, a row of rose-colored or sometimes brownish spots or bars along middle of back; eyes rose colored; joints of peduncle of antennæ yellowish at tip; a dark bar across tip of abdomen and base of uropods; gills with a tinge of rose color.

Length, 2 mm.

This species was taken in material obtained from piles at Woods Hole, Mass., September, 1900, and among masses of *Pennaria* from Grassy Island. It is easily recognized by its enormous fourth coxal plates, which give the animal an appearance much like some of the Cladocera. All of the thoracic legs, when drawn up to the body, are entirely concealed by the large coxal plates. This species swims in an irregular, jerky manner, and after swimming but a short distance suddenly stops, flexes the body, and drops to the bottom. Its motions in the water resemble those of the ostracod *Cypris*.

**Stenothoë minuta** Holmes, new species.

Eyes round; antennæ of subequal length and a little over half length of body; first joint of first pair very much thicker than second and nearly as long as second and third; flagellum slender, about twelve-jointed, furnished with short setæ and olfactory clubs; second antennæ with last two joints of peduncle of nearly equal length, flagellum with somewhat fewer joints than in first pair; mandibles without palp, the cutting edge divided into numerous teeth; first maxillæ with inner plate small and bearing a single large seta near distal end; outer plates with five stout spines at distal end, one of which is quite short, and a single, stout, pointed seta at outer end of spine row; inner margin furnished with short setæ; palp two-jointed, distal end of second joint furnished with a few spines and setæ; maxillipeds with inner plates minute, distally rounded, and having two short setæ each on distal end; outer plates absent, ischium having but a minute angular point at inner angle; first two joints of palp



*Stenothoë minuta.* Woods Hole, Mass

of equal length and about as broad as long; third joint nearly as long as first and second; last joint claw-like, strongly incurved, inner margin pectinated from very near base to tip, spines decreasing in length distally; first gnathopods with coxal plates reduced; basal joint with a few slender spines on anterior margin; merus rounded below, where it is furnished with four spine-like setæ and several much shorter setæ; carpus produced posteriorly into a small rounded lobe, which has about three large, spine-like setæ at its distal end; hand nearly twice as long as wide; palm very oblique and minutely pectinated like inner margin of dactyl; second gnathopods larger than first, coxal plate large, oval in outline with one side flattened; basal joint more or less sigmoid; merus produced below into an acute angle; carpus with a narrow, distally rounded posterior lobe which bears numerous short, stiff setæ and three large setæ at the tip; hand widest across distal end of palm; palm oblique, only slightly curved, not pectinated, distal end armed with two or three pairs of spines; peræopods of subequal length, posterior pairs with basal joints considerably expanded, and merus rather broad and produced downward at postero-inferior angle; dactyls of all peræopods large; first uropods long and slender with lanceolate rami subequal and nearly equal to peduncle; outer ramus of second uropods markedly shorter than inner; the single ramus of terminal uropods about as long as peduncle; basal division a little shorter than conical terminal one and armed with a spine at distal end of upper margin; peduncle with a spine above near middle and a spine at distal end; telson flattened, oblong, pointed, entire, with three small spines near lateral margins.

Found upon piles and among seaweed at Woods Hole.

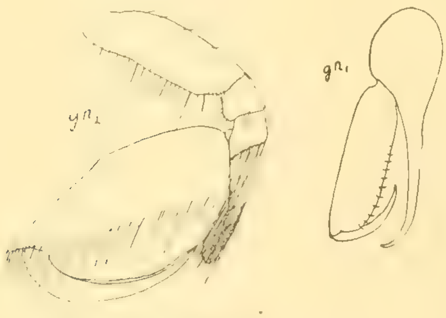
Pellucid, marked with scattered reddish-brown spots. A reddish-brown band across end of abdomen. Thorax in some specimens crossed with red bands. Eyes bright red.

Length, about 2½ mm. Type No. 29245, U. S. Nat. Mus.

### **Leucothoë spinicarpa** Abildgaard.

*Leucothoë grandimanus* Stimpson, Marine Invert. Grand Manan, p. 51, 1853. Bate, Cat. Amphip. British Mus. p. 157, pl. XXIX, fig. 4, 1862.

Rostrum very short and obtuse; eyes broadly oval, red; antennæ of subequal length and less than half as long as body; peduncle of first antennæ with first joint about as long as second and produced into small acute lobe at distal end of lower side; third joint not a fourth as long as second; flagellum scarcely two-thirds length of peduncle and composed of about 16 joints; second antennæ with last joint of peduncle shorter than preceding one but a little longer than flagellum; first four coxal plates a little deeper than their segments, the first produced forward and rounded or truncated in front; carpus of first gnathopods produced into a slender, tapering process which is as long as propodus and is upturned at its distal end; propodus of nearly same width throughout, minutely serrated below, and furnished with a series of evenly spaced curved setæ; dactyl slender, curved, and between one-third and one-half length of propodus; second gnathopods with the carpal process extending as far as palm; hand large, especially in the male; oval in outline, with a sharp process above base of dactyl; palm minutely denticulated or serrulate; postero-lateral angle of third abdominal segment produced into a small tooth; telson narrow, elongate, acuminate.



*Leucothoë spinicarpa*, female. Grand Manan.

Length, 15 mm.

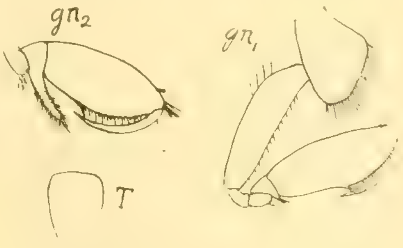
Arctic regions; east side of the Atlantic from Norway to the Mediterranean and the Azores; Greenland (Hansen); Grand Manan (Stimpson).

A specimen examined from Grand Manan, the type locality of Stimpson's *L. grandimana*, was found to agree perfectly with the description and figures of *spinicarpa* given in Sars's Crustacea of Norway. I have also compared this specimen with several specimens of *spinicarpa* received from Great Britain through the kindness of the Rev. T. R. R. Stebbing.

### **Paroediceros lynceus** (M. Sars).

*Œdiceros lynceus* M. Sars, Oversigt Norsk-Arctiske Region Krebsdyr., p. 25.
*Monoculodes nubilatus* Packard, Mem. Bos. Soc. Nat. Hist., Vol. I, pt. 2, 1867, p. 298, pl. VIII, fig. 4.

Eyes oblong, contiguous, situated near end of blunt rostrum; first antennæ about half as long as second, which are not a third the length of body and have peduncle and flagellum of subequal length; first four coxal plates large, the first produced forward in the middle; second and third subrectangular, much deeper than wide; fourth about as broad as deep; fifth rather large, with anterior and posterior divisions equal; body smooth, without spines; first four abdominal segments with more or less of a median dorsal carina; lateral wings of first three abdominal segments with lower margins broadly rounded, setose, and devoid of any angular projections or teeth; first two gnathopods of subequal size; first pair with carpus very small, pointed behind, but not produced into a prominent lobe; hand gradually narrowing toward base, palms long, oblique, convex, with a spine at its distal end, fingers very narrow, fully half as long as hand; carpus of second gnathopods produced into a long, narrow, setose lobe which lies close to posterior margin of hand and extends as far as distal end of palm; hand oval, palm evenly curved, with a spine at its upper end; rami of first uropods shorter than peduncle; those of second about equal to peduncle, while those of terminal pair much exceed peduncle; margins of rami armed with a very few distant spines; telson oblong, rounded at tips.



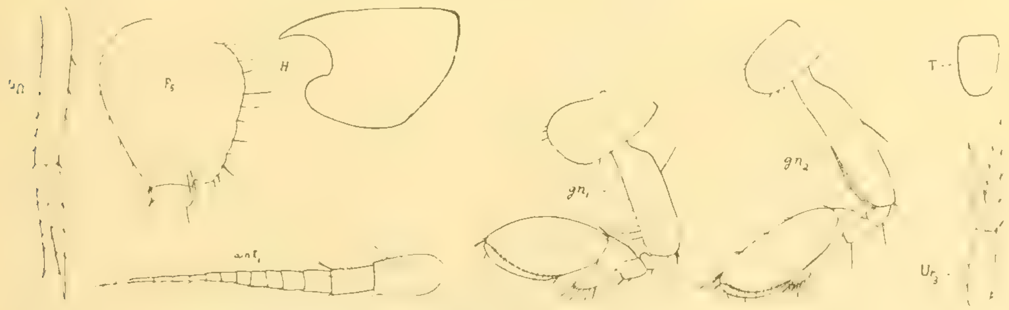
*Paræediceros lynceus*, female. After Sars.

Length, 18 mm.

Arctic and North Atlantic oceans; Norway; Greenland (Hansen); Labrador (Packard, Smith); south of Halifax, Nova Scotia, in 85 fathoms (Stebbing); Grand Manan; Eastport, Me.; off Cape Ann, 25 fathoms.

### **Monoculodes edwardsi** Holmes, new species.

Rostrum triangular, rounded above, and curved downward, reaching about to tip of first joint of antennular peduncle; antero-lateral lobes of head broadly rounded; eyes at base of and but little upon rostral projection; first antennæ but slightly exceeding peduncle of second; first joint of peduncle about as long as next two; flagellum considerably longer than peduncle and composed of about 14 joints; second antennæ over half length of body; last joint of peduncle as long as the two preceding ones; flagellum about twice length of peduncle and composed of numerous (over 60) short articulations; mandibles with second joint of palp bent inward, third joint about equal to second in length and setose at tip and on inner margin nearly to base; inner lobes of lower tip well developed; inner plate of first maxillæ suboval, with two setæ at tip; outer plate with eight spines, some of which are furcate; first joint of palp longer than broad; second joint spatulate, setose distally and on distal third of inner margin and having two setæ on distal third of outer margin; maxillipeds with inner plates small, oblong, not reaching the distal end of first joint of palp, distal end rounded and furnished with



*Monoculodes edwardsi*. Near Woods Hole, Mass. *H*, head; the eyes were so indistinct in the specimen drawn that no attempt was made to figure them.

about eight setæ; outer plates reaching only a little beyond middle of broad second joint of palp, inner margins armed with about ten strong spines, which increase rapidly in length toward distal end, where there are two setæ, which form a continuation of the spine row; outer margin without setæ; palp large, terminal joint a stout, nearly straight claw; coxal plates unusually small; first gnathopods with carpal lobe long, distally setose; hand oval, palm evenly convex, a little larger than posterior margin of hand, and furnished with a spine at distal end; second gnathopods with carpal lobe slender, extending along posterior side of hand as far as palm; hand oblong, palm about as long as posterior margin of hand and armed with a spine at distal end; propodi of first and second peræopods short, with several tufts of very long setæ on both margins; dactyls over half length of propodi; third and fourth peræopods with merus broad and produced into an obtuse triangular lobe at postero-inferior angle; dactyls over half length of propodi; last peræopods with basal joint nearly as wide at base as it is long; propodus longer than merus or carpus, and about equaling styliform dactyl; third abdominal segment with postero-lateral angles rounded; rami of first uropods shorter than peduncle; those of last uropods a little longer than peduncle; telson oblong, distally rounded.

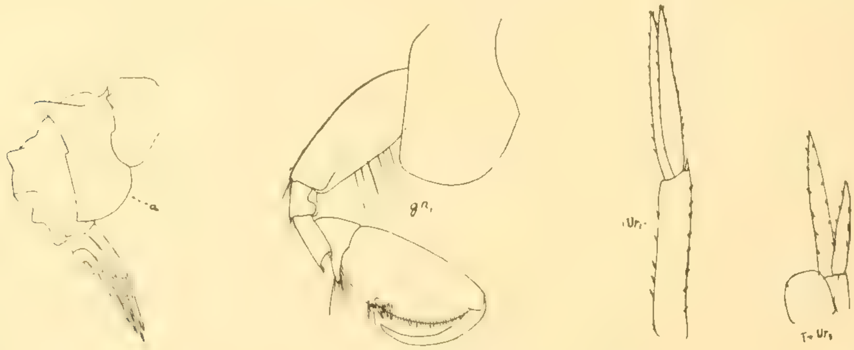
Length of specimen examined, 9 mm.

Described from a single specimen taken by Mr. V. N. Edwards at Woods Hole, Mass., along with specimens of *Calliopius læviusculus* and *Gammarus*. The eyes could not be seen with distinctness. Several smaller specimens, which were taken by Mr. Judd at Newport, were examined. In several of these the rostrum was curved downward more strongly than in the specimen figured. Type No. 29243, U. S. Nat. Mus.

### **Pleustes panoplus** (Kröyer).

*Amphithonotus cataphractus* Stimpson, Marine Invert. Grand Manan, p. 52, 1853.

Rostrum well developed, triangular, acute, concave above, furnished with a median ridge below, and curved slightly downward; eyes rounded, convex, situated widely apart; antennæ short, scarcely half length of thorax and of subequal length; first joint of first pair a little longer than next two and very much thicker; flagellum larger than peduncle; last two joints of peduncle of second antennæ of subequal length; flagellum a little shorter than peduncle; thorax broad, with a median dorsal carina on all segments; lateral margins of segments produced into a ridge, which in last three or four segments is produced posteriorly into a tooth; a tooth on posterior margin of last two thoracic segments on either side of dorsal carina; first three segments of abdomen furnished with a median dorsal keel which decreases in height posteriorly; a carina on either side of the middle on all abdominal segments, represented on the first segment by a tooth on the posterior margin, on the second segment by a large flattened tooth which projects behind the posterior margin, on the third by a ridge which is produced into a tooth near the middle, on the fourth by a ridge which is elevated near its anterior and at its posterior end; a small tooth on posterior margin of first two abdominal segments below lateral carinæ; postero-lateral angles of second and third segments of abdomen acute; first four coxal plates large,



*Pleustes panoplus.* Labrador. *a*, Abdomen and uropods.

deeper than long, and deeper than their respective segments, the fourth deeply excavated at upper posterior angle; last three coxal plates acute behind, first two (fifth and sixth) ridged along lower side; mandibles with second joint of palp twice length of first and almost as long as third; first maxillæ with outer plate but little longer than its breadth at base and armed distally with nine dentigerous spines; second joint of palp over twice length of first, and armed around tip and on distal third of inner margin with eight or nine very short spines; maxillipeds with inner plates broad and very short, not quite reaching distal end of outer part of ischium; outer plates small, oblong, not quite reaching tip of first joint of palp; fourth joint of palp claw-like, smooth; gnathopods of subequal size and similar form; merus with postero-inferior angle acute; carpus with a very narrow, setose posterior lobe; propodus large, subovate, palm convex; dactyl, when closed, fitting into a small pocket at upper end of palm; outer ramus of posterior uropods markedly shorter than inner; telson subquadrate, with broadly rounded posterior angles.

Stimpson describes the color of this species as "very variable, generally dark reddish or brown, variegated, and mottled with white. Some specimens were of a uniform deep purple, others pure white. Eyes yellowish or vermilion colored, with a black dot in the middle."

Length, 15 mm.

Stimpson states that this species, when disturbed, "rolls itself up and remains quiescent, as if feigning death. * * * When in motion this animal preserves an erect posture, like the isopods, with its tail bent up underneath. It seldom swims, but makes powerful leaps by means of its well-developed caudal stylets."

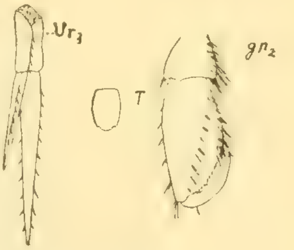
Grand Manan (Stimpson), taken "in 10 fathoms on a sandy bottom inside of Duck Island ledge"; Henley Harbor, Labrador, "at a depth of 4 fathoms among weeds" (Packard); Gulf coast of Labrador (Smith); Eastport, Me.

My description and figures of this species are taken from a single imperfect specimen from Eastport, Me., collected by Professor Packard and belonging to the Boston Society of Natural History.

### **Paramphithoë pulchella** (Kröyer).

*Paramphithoë euacantha* Sars, Norske Nordhavs-Exped., p. 168, t. XIV, fig. 3, 1885.

Thorax and first three abdominal segments with a prominent dorsal crest which on posterior segments of thorax and first three segments of abdomen is produced posteriorly into large, oblique, compressed spines. In some specimens the dorsal carina appears as far forward as the first thoracic segment, but the first three segments and often the fourth have no posterior spinous projection; fourth abdominal segment with a triangular compressed elevation above, but no true spine; postero-lateral angles of second and third abdominal segments (and to a less extent the first also) produced into an acute tooth; head with a broad obtuse rostrum and projecting, subacute lateral angles; eyes broadly oval or nearly round; first antennæ nearly as long as body, first basal joint as long as next two; second antennæ seldom much over half length of first; first coxal plates tapering to a subacute point below, the three following ones with lower margin rounded; gnathopods similar; hand oblong, widening somewhat distally; palm oblique, smooth except for a minute tooth not far from middle; the three posterior peræopods nearly equal; terminal uropods slender, outer ramus a little over half length of inner one; telson oblong, distally rounded, with a minute projection on either side of tip.



*Paramphithoe pulchella*. After Sars.

Length 17 mm.

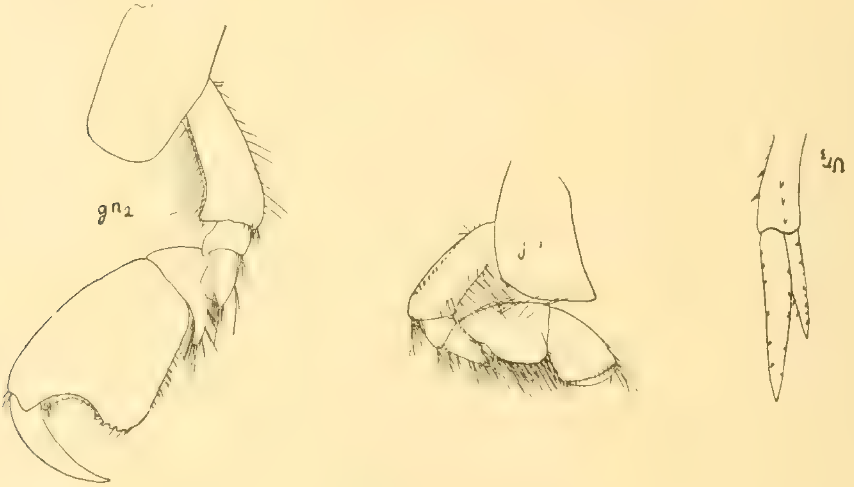
Widely distributed in the Arctic Ocean; Greenland (Kröyer); Norway (Sars); Labrador (Grand Manan).

The specimen figured approaches the form described by Sars as *P. euacantha*, but which that author subsequently concluded, in agreement with Hansen, was "only an excessively developed variety" of *pulchella*.

### Sympleustes latipes (M. Sars).

*Calliope ossiani* Bate, Cat. Amphip. Brit. Mus., p. 149, pl. XXVIII, fig. 3, 1862.
*Calliope fingalli* Bate & Westwood, British Sessile-eyed crustacea, Vol. I. p. 263
*Parapleustes latipes* Sars, Crust. Norway, Vol. I, p. 360, 1895.
*Sympleustes latipes* Stebbing, Ann. Mag. Nat. Hist. (7), Vol. IV, 1899, p. 209.

Head produced into a small rostrum; eyes light colored in alcohol; first antennæ over half length of body, first joint of peduncle longer than second; third joint much narrower than second and scarcely half as long, and not having a prominent lobe at inferior distal angle; second antennæ much shorter than first and more slender, peduncle about reaching tip of peduncle of first pair and nearly as long as flagellum; first gnathopods small, quite strongly setose especially on posterior margins of merus and carpus; merus produced below into a rather narrowly rounded lobe, carpus larger than hand, hand narrowed toward base, distal end of oblique palm furnished with a few spines, second gnathopods very much larger than first; carpus short, produced posteriorly into a long narrow lobe which is curved downward; hand large and stout oblong, widening distally to palm, which is transverse, somewhat concave in the middle, distal end broadly rounded and furnished with several short but stout spines; peræopods stout, the last three pairs with basal joints considerably expanded and similar in form, and merus joints dilated and produced at postero-inferior angle into a triangular projection which extends downward beyond middle of next joint; first three segments of abdomen and, to a less extent, last segment of thorax somewhat elevated posteriorly and more or less carinate; postero-lateral angles of second and third abdominal segments produced into a small acute tooth; uropods all extending backward to about the same point; rami nearly equal to peduncle in first pair and of nearly equal length. In second and third pairs inner ramus much longer than outer and exceeding peduncle; telson ovate with subacute or acute tip.



*Sympleustes latipes.* Grand Manan.

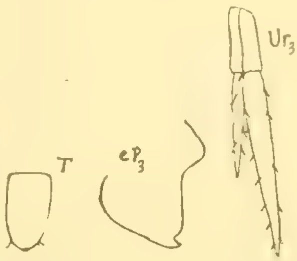
Length, 15 mm.

Grand Manan, 45 fathoms, one specimen; Greenland; Norway; British Isles

### Sympleustes glaber (Boeck).

*Sympleustes glaber* Stebbing, Ann. Mag. Nat. Hist. (7), Vol. IV, 1899, p. 209.

Body smooth and evenly rounded; head with a small rostrum and very prominently projecting and somewhat upturned lateral angles; eyes somewhat irregularly rounded; first antennæ about two-thirds length of body, first joint of peduncle larger than next two and having a spine-like process on lower side of distal margin; second antennæ shorter than first, last joint of peduncle shorter than preceding one; flagellum larger than peduncle; first four coxal plates deeper than wide and considerably deeper than their segments, the first three with a small but conspicuous denticle at the postero-inferior angle; first and second gnathopods of not very unequal size (the first a little smaller), and of similar form; merus with a spiniform projection at the postero-inferior angle; carpus subtriangular with a posterior setose lobe which is more prominent in the second gnathopod than in the first; hand much larger than the three preceding joints, oblong-oval in outline, palm evenly curved; margin laminate and furnished with a short tooth, or spine, near the middle, and two fascicles of stout spines, one behind the other, at distal end; dactyl evenly tapering, smooth within, and furnished with two or three setæ near tip; when closed, the dactyl fits between the spines of the distal end of the palm; three posterior peræopods with basal joint large, oval, and serrated on posterior margin; postero-inferior angle of merus produced strongly downward; postero-lateral angles of third abdominal segment with a small, somewhat upturned tooth, a short distance above which is a convexity of the posterior margin; uropods rather slender, last pair with inner ramus nearly twice as long as outer; telson nearly twice as long as wide and distally rounded.



*Sympleustes glaber.* After Sars. *$ep_3$*, Side plate of the third abdominal segment.

Length, 6 mm.

Greenland, Iceland, Spitzbergen, Norway (Sars).

A single imperfect specimen was examined, which was taken by Hyatt and Van Vleck from Eastport, Me. It agrees perfectly with the description and figures of this species in Sars' Crustacea of Norway, except that the lateral lobes of the head are rounded instead of acute.

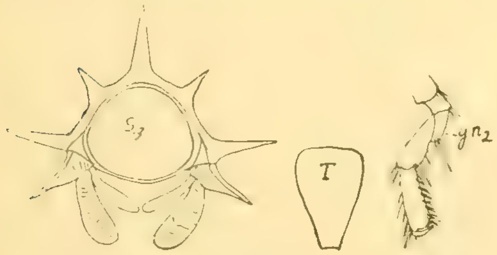
### Epimeria loricata Sars.

*Epimeria cornigera* Verrill (not Fabricius).

Head produced into a long rostrum which is rounded above and curved downward; eyes nearly round, protruding; antero-lateral angle of head produced and acute; first antennæ shorter than second, first joint of peduncle wide, longer than next two; flagellum over twice length of peduncle; second antennæ scarcely half length of body; last joint of peduncle two-thirds length of preceding one; thoracic segments with a median crest which becomes higher posteriorly, and is continued upon first four segments of abdomen, posterior ends of crest of each segment becoming successively more acute toward posterior end of body; two rows of tubercles on either side of median crest extending from the first thoracic to third abdominal segment; in lower row but one tubercle to each segment, and in the upper row one tubercle to each thoracic segment, but three upon each of first three segments of abdomen; coxal plates very large, first three narrow, acute below, antero-lateral angle of fourth and postero-lateral angle of fifth coxal plates strongly produced, acute, and bent outward; first two gnathopods similar in size and shape; hand oblong, small, palm only slightly oblique; third and fourth peræopods with basal joints deeply excavated behind, forming grooves with sharp margins; fifth peræopods shorter than fourth, basal joint laminately expanded behind, narrowing in distal half; uropods with flattened subequal lanceolate rami which are larger than peduncles; telson broad, with a triangular notch at tip.

Length, 30 mm.

Arctic regions and North Atlantic Ocean: New England, off Head Harbor, 50 fathoms.



*Acanthozone cuspidata.* After Sars. *$S_3$*, The third segment of the thorax.

### Acanthozone cuspidata (Lepechin).

Body covered with numerous large spines. On the thorax the spines are arranged in five rows, one median dorsal row of very large spines, a lateral row of large nearly horizontal spines on either margin, and a row between these and the median dorsal spines; first thoracic segment with a large spine projecting nearly horizontally over the head; first three abdominal segments with a very large median spine and several spines on either side upon posterior margin; fourth segment with a small median spine and, as in the fifth segment, with a recurved hook at the postero-inferior angle; rostrums small; first basal joint of first antennæ produced distally into a spine; first three coxal plates acuminate below, first bent forward; fourth with two inferior spinous projections; gnathopods similar, hand long, narrow, with a short, nearly transverse palm; basal joints of three posterior peræopods with two large spinous processes on posterior margin; telson narrowly truncated at tip.

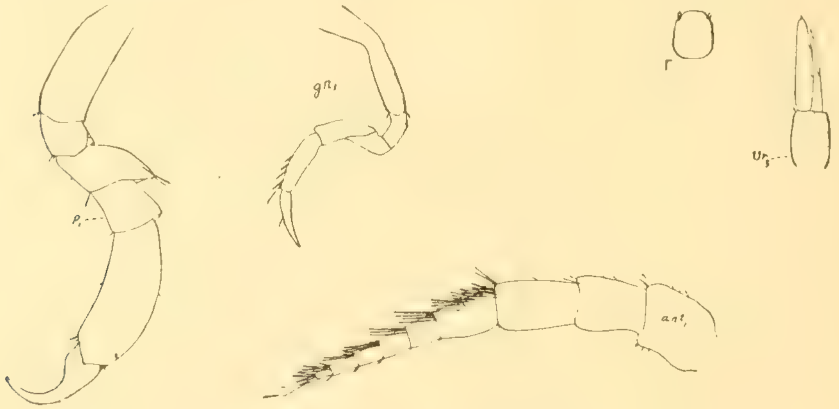
Length, 19 mm.

Widely distributed in the Arctic regions; Greenland; Labrador; Grand Manan; Eastport, Me.; off Cape Ann.

This is one of the most peculiar and striking of the Amphipoda of our coast and is easily distinguished from all the other forms by the abundance and large size of its spines.

### **Lafystius sturionis** Kröyer.

Body robust, depressed; head short and broad, with a broad and obtuse rostrum; eyes rather small, nearly round, and containing few facets; first antennæ slightly longer and much stouter than the second, less than half the length of the body; the three joints of peduncle of nearly equal length, the second a little the shortest; flagellum seldom longer and often shorter than peduncle and composed of six or seven segments, which are furnished with long olfactory clubs; second antennæ weak, peduncle not much thicker than flagellum, the latter composed of five or six elongate segments; maxillipeds with very narrow inner plates, which bear two or three setæ on inner margin and a pair of small setæ at tip; the large outer plate pectinated and furnished with a few large setæ distally; the small two-jointed palp not reaching tip of outer plate; thorax tumid, first two segments shorter than others, coxal plates small; first gnathopods small, very slender, simple propodus very narrow, dactyl styliform nearly straight and a little irregular in outline; second gnathopods small, joints, except the first, short, hand produced and rounded at postero-inferior angle, dactyl bifid at tip; peræopods well-developed and of not very unequal length, merus of first and second pairs dilated and produced downward in front; propodus in all peræopods large and stout, dactyls large, smooth, hook-like; in the first pair the propodus is stouter, and the dactyl stouter and more curved than in succeeding peræopods; uropods armed with very few spines; rami narrow, nearly equal to peduncle in first pair, a little longer than peduncle in second pair, and very much longer than peduncle in third.



*Lafystius sturionis*, male. Woods Hole, Mass.

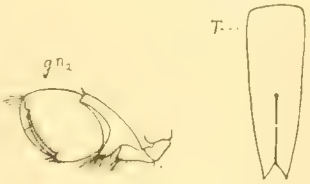
Length, 6 mm.

From the mouth of a goose-fish, *Lophius americanus*, taken in Vineyard Sound (Smith); "From the back of a skate (*Raia laevis*) in the Bay of Fundy" (Smith); Halifax, "parasitic on *Cottus*" (Stebbing); Scandanavian coast (Sars and others); Mediterranean, on *Lophius piscatorius*, (Della Valle); British Isles.

The above description with the figures accompanying it were taken from specimens obtained from goose-fish taken near Woods Hole.

### **Eusirus cuspidatus** Kröyer.

Head with a short, pointed rostrum, which is rounded above and curved downward; eyes reniform, pale in alcoholic specimens; first antennæ scarcely half length of body; second segment as long as first and over twice the length of third; secondary flagellum minute, one-jointed; second antennæ nearly as long as first; last joint of peduncle nearly as long as preceding one; flagellum a little shorter than peduncle; first four coxal plates of subequal depth, the first produced forward and rounded at lower angle; second and third equal, twice as deep as wide, rounded below; fourth nearly as wide as deep, deeply excavated at upper posterior angle; first and second gnathopods subequal in size and similar in form, carpus attached near middle of anterior margin of hand, a narrow process extending down posterior margin half way to palm; palm long, evenly curved, defined posteriorly by a small prominence; dactyl long, slender, fitting closely to palm; first and second peræopods slender and elongate; three posterior pairs increasing successively in length, posterior margins of expanded basal joints serrate; last segment of thorax and first two segments of abdomen with a median dorsal spine at posterior end; the first four segments of abdomen and to a less extent the last segment of thorax with a median dorsal carina; fourth segment with a marked depression above a little in front of middle; postero-lateral angle of third segment of abdomen produced and acute; that of fourth segment broadly rounded and armed with numerous upturned serrations; much less evident serrations on the postero-lateral margins of first two segments; uropods extending backward to nearly the same point; peduncle of first pair with a large spine on outer side of distal extremity; outer ramus relatively much shorter than inner in second uropods than in first or third; telson long, narrow, flattened, grooved above, with a narrow fissure at posterior end which extends nearly to middle.



*Eusirus cuspidatus.* After Sars.

Length, 17 mm.

Norway; Arctic regions; Greenland; Grand Manan.

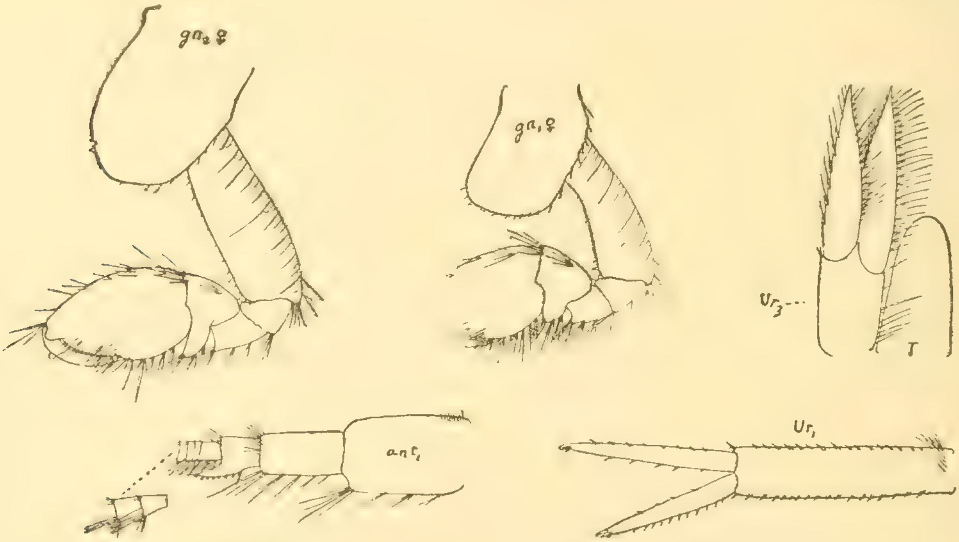
### **Rhachotropis aculeata** (Lepechin).

Head with a prominent, acuminate rostrum which is slightly curved downward; eyes prominent, tenuid, their inner ends obtusely pointed; a rounded prominence between posterior ends of eyes; first antennæ nearly as long as second, first basal joint thick, flattened; third joint about one-third length of second, which is shorter than first; flagellum subequal to base; thorax broad, last two segments with three strong spines on posterior margin, last segment considerably longer than preceding ones; first five segments devoid of spines with exception sometimes of a trace of a spine on the mid-dorsal line of fifth; coxal plates small, first strongly produced in front and incurved at its anterior angle; fourth and fifth with a short longitudinal eminence on outer surface; first two gnathopods similar; carpus short, with a narrow posterior lobe; hand large, ovate, a prominence at upper end of the evenly convex palm; all of the peræopods with slender, elongate, slightly-curved dactyls, basal joints of fourth and fifth pairs with a large tooth on proximal portion of posterior margin; last peræopods much longer than others, basal joint much expanded proximally, the posterior margin strongly sinuous with a large tooth at lower end; first three abdominal segments flattened at sides, with three longitudinal dorsal carinæ, each of which ends on the posterior margin of its segment in a spine, the middle carina having a smaller spine near the middle of each segment; fourth segment with a median carina furnished with two spines as in preceding segments, a small lateral carina on either side which bears no spine and does not reach posterior margin of the segment; telson narrowly triangular with a broad groove, apex cut with a long narrow incision.

Several specimens taken off the coast of New England measured from 20 to 28 mm. A large specimen from the Arctic Ocean received from Doctor Stebbing measured 38 mm. This is one of the largest of our species of amphipods, and is extensively distributed in the Arctic regions. It is reported from Labrador by Packard and Smith and by the latter also from northern New England. I have examined specimens collected off Cape Ann in 25 fathoms, which is as far south as I have any knowledge of its occurrence. It is found in rather deep water.

### Calliopius læviusculus (Kröyer).

Head with a small, triangular rostrum; eyes rather large, reniform; first antennæ somewhat shorter than second, the first basal joint considerably thicker and a little longer than second, third joint with inferior process long and narrow and furnished below with about eight calceolæ; flagellum a little longer than peduncle, joints very short at base but distally longer than broad and produced at antero-inferior angle; each joint with a pair of calceolæ and several olfactory setæ on the lower side and a few very short setæ above; second antennæ about two-fifths the length of body; last two basal joints of subequal length, the penultimate reaching as far as penultimate basal joint of first antennæ; flagellum subequal to peduncle, joints not produced below and each furnished with a pair of calceoli on median side; first four coxal plates deeper than broad, about as deep as their segments, and increasing successively in length, the first produced at anterior angle; first two gnathopods of similar form and of nearly equal size, the second a little the larger, with lobe on posterior side of carpus longer and narrower; hands ovate, palm very oblique with a row of stout spines on outer side which begins a little beyond middle of palm and a little above its distal end; gnathopods of male similar to those of female, but stouter; merus of first two peræopods strongly produced downward at anterior angle; merus of three posterior peræopods strongly produced downward at posterior angle, that of last pair more dilated than in preceding ones; first three abdominal segments more or less protruding at posterior end, especially in older specimens; postero-lateral angles of second and third segments with a small tooth; second, third, and fourth, and often, but to a less extent, the first, segments more or less indented above near base; first uropods with outer ramus markedly shorter than inner, which is somewhat shorter than peduncle; both margins of both rami and peduncle armed with numerous short spines; peduncle of second uropods relatively much less narrow than that of first, somewhat shorter than inner ramus; outer margin armed with about five spines, inner with several more; outer ramus much shorter than inner; both margins of both rami armed with numerous short spines; terminal uropods extending beyond the others; rami flattened, lanceolate, subequal, much longer than peduncle, with both margins of each furnished with numerous spines and plumose setæ; telson oblong, slightly tapering and rounded at tip.



*Calliopius læviusculus.* In connection with the antennæ, two of the more distal segments of the flagellum are shown.

Length, 16 mm.

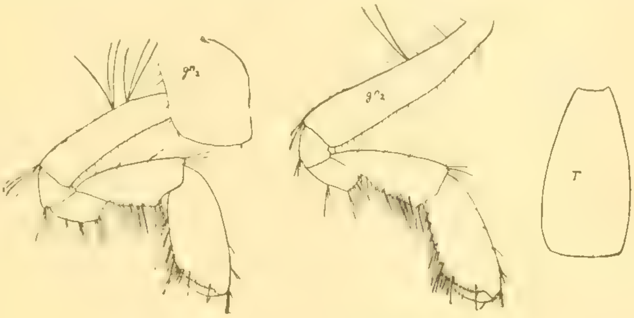
Narragansett Bay (Judd); Vineyard Sound (Smith); Woods Hole; Gloucester; Grand Manan; Halifax; Labrador; Greenland; Arctic regions; Norway; British Isles.

I have examined numerous specimens and find transitional stages between forms which Sars describes as *Calliopius rathkei* and those he refers to *læviusculus*. Smaller specimens usually present the characteristics of *rathkei*.

### **Halirages fulvocinctus** (M. Sars).

*Pherusa tricuspis* Stimpson, Proc. Acad. Nat. Sci. Phila. 1862, p. 139.
*Atylus* (*Paramphithoe*) *inermis* (Kroyer fide Boeck) Packard, Mem. Bos. Soc. Nat. Hist., Vol. I, 1867, p. 298, pl. 8, figs. 3-3b.

Head with a small, downwardly curved rostrum; eyes large, broadly reniform, pale in alcoholic specimens; both pairs of antennæ long and slender, the first, which is usually a little the longer, often exceeding length of body; peduncle of first antennæ with first joint longer and stouter than second; third joint shorter than the second, with its antero-inferior angle produced into a laminate, pointed process which is furnished below with calceoli, as are also the lower margins of second and of basal portion of third segment; segments of flagellum with calceoli on lower side of each; second antennæ with last two basal joints subequal, penultimate one reaching distal end of peduncle of first antennæ; flagellum and last two joints of peduncle with calceoli along upper margin; first four coxal plates of moderate size, scarcely as deep as their segments, the fourth about as wide as long and concave behind; last segment of thorax and first two segments of abdomen produced posteriorly in mid-dorsal line into a large spine; lateral portion of first abdominal segment broadly rounded below, with a minute cusp a little behind middle of lower margin; postero-lateral angle of second abdominal segment projecting as a small tooth, above which the posterior margin presents an angular prominence; postero-lateral angle of third abdominal segment with a prominent tooth, above which the posterior margin bears a large upturned tooth; margin between these two teeth serrated; gnathopods small, nearly equal in size and of similar form; basal joint elongate, curved forward in the first and a little backwards in the second; carpus long, a little broader relatively and a little more obliquely truncated at postero-distal angle in first than in second pair; hands narrow, palm oblique, with a row of four spines on outer side at distal end; uropods with flattened, narrow rami; first two pairs with outer ramus markedly shorter than inner and tip of each ramus armed with a cluster of spines; second uropods markedly shorter than first or third, third extending backward only a little farther than first; rami of third uropods of nearly equal length and over twice length of peduncle, much broader than those of preceding uropods, and lanceolate in form, terminating not in a cluster of spines but in an acute tip; telson oblong, tapering distally, concave above, tip with a shallow emargination.



*Halirages fulvocinctus.* Ipswich Bay, Mass.

The color, according to M. Sars, is "a pellucid yellowish-white marked with rings of brownish-yellow in the posterior dorsal margin of each segment; antennæ with brownish rings; eyes red."

Length, 17 mm.

Arctic regions; Labrador (Packard, Smith); "south of Halifax, Nova Scotia; latitude 43° 3′ N., longitude 63° 39′ W.; depth 85 fathoms" (Stebbing); Ipswich Bay, 27 fathoms.

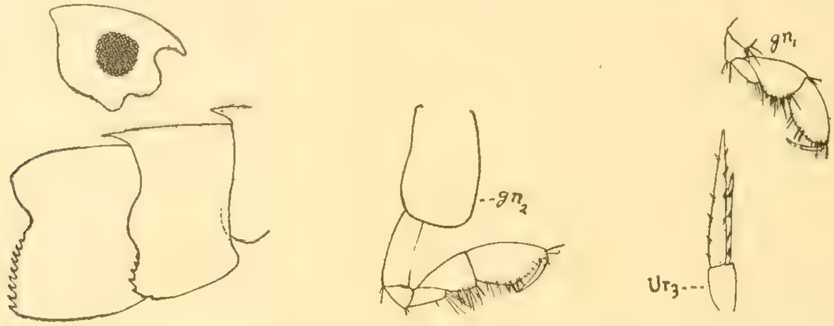
In some of the specimens which I have examined the first antennæ are shorter than the second, while in others they are longer, sometimes exceeding the length of the body, as described by M. Sars.

### **Apherusa gracilis** Holmes, new species.

Head with front obtuse, curved downward; eyes large, pale in preserved specimens; lateral corners of head rounded; first four coxal plates well developed, much higher than their segments, the first somewhat expanded distally, fourth about as wide as deep and slightly emarginate posteriorly; gnathopods similar; carpus in first pair a little wider than propodus, evenly rounded and setose posteriorly; hand oblong-oval, scarcely longer than carpus; palm evenly convex and not sharply marked off from posterior margin and bearing a pair of spines near the end; second gnathopods with carpus subtriangular, much less convex posteriorly than in first gnathopods; hand oblong, longer and broader than carpus, widest near upper end of palm, where there are a few spines; first two segments of abdomen with a dorsal posterior spine; third segment rather abruptly bent downward at posterior end but not produced into a spine; postero-lateral margin of second abdominal segment with convexity near the middle, below which are several upturned teeth which are continued around the rounded lower angle; postero-lateral margin of third segment of abdomen armed with several prominent upturned teeth; uropods elongated, last pair with the longer ramus nearly three times length of peduncle and armed with five or six spines on the inner and four or five spines on the outer margin; outer ramus about two-thirds length of inner and armed with four spines on outer margin; telson oblong, entire, and distally rounded.

Length, 5 mm. Type No. 29242, U. S. Nat. Mus.

Described from two rather imperfect specimens taken off Gay Head, Marthas Vineyard. The flagella and last basal joint of first antennæ were broken off; first basal joint of these appendages longer and stouter than second, as in the other species of this genus; second antennæ shorter than body; last two joints of peduncle of subequal length and joints of flagellum narrow, sparingly setose and devoid of calceolæ; terminal joint of mandibular palp considerably shorter than preceding one and with inner margin slightly concave and outer margin convex. Anterior portion of first three abdominal segments crossed by a light band. Body and appendages with numerous dark pigment cells. Eyes red.



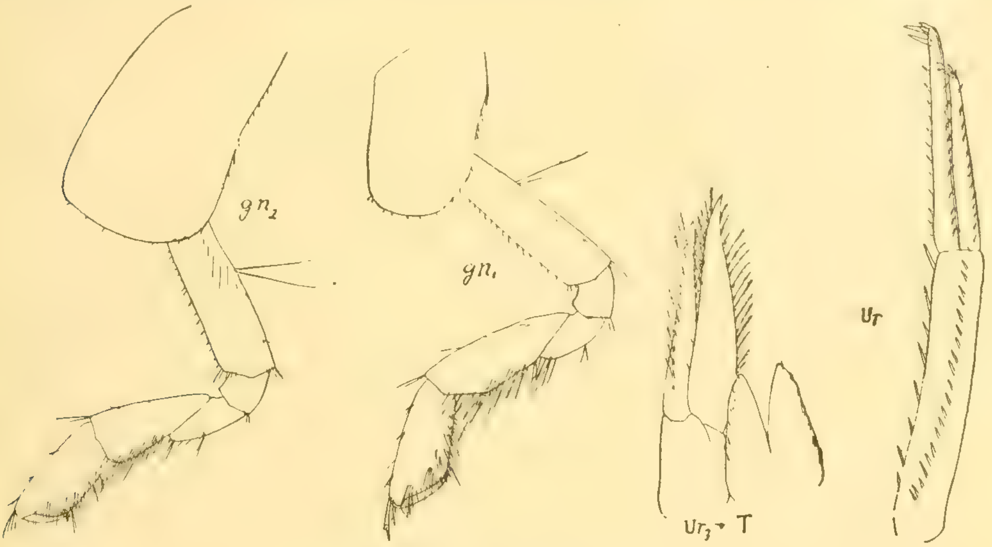
*Apherusa gracilis.* Gay Head. The figures on the left represent the head and the first three segments of the abdomen.

From *Apherusa jurinii* and *A. borealis* this species differs in having the postero-lateral margin of the third abdominal segment armed with numerous teeth. From *A. bispinosa* it differs in that the carpus and propodus of the first and second gnathopods are much shorter and broader, and in having no large tooth at the upper end of the row of dentations on the postero-lateral margins of the third abdominal segment. It presents the same points of difference from *A. megalops*, besides having smaller eyes and having the lateral corners of the head rounded instead of produced and acute. It approaches *A. tridentata* in the armature of the sides of the abdomen, but differs from that species in having the carpus of both gnathopods very much broader, in having the outer ramus of the terminal uropods relatively shorter, and in not having the posterior margin of the telson serrated.

### Pontogeneia inermis (Kröyer).

*Iphimedia vulgaris* Stimpson, Marine Invert. Grand Manan, p. 53, 1853

Rostrum narrow, prominent, but not large; antero-lateral angle of head acute; eyes rather large, broadly reniform, fading to a pale color in alcoholic specimens; antennæ slender, first somewhat shorter than the second, with first two joints of peduncle of subequal length, the third two-thirds length of second; flagellum slender, over twice length of peduncle; second antennæ over half length of body; last two basal joints subequal; flagellum over twice length of peduncle; flagella of both pairs of antennæ furnished with short setæ, and on first are small groups of olfactory hairs on alternate joints; first four coxal plates about as deep as their segments, first three deeper than wide and of similar form; gnathopods small, of nearly equal size and of similar form, the narrow basal joints of each with numerous very short setæ on anterior margin and a few very long setæ posteriorly; carpus of first pair long and narrow, longer than propodus, obliquely truncated at postero-inferior angle, posterior margin furnished with several tufts of setæ, in each of which is one or more very thick plumose setæ and several more slender simple ones; hand oblong, narrow, narrowing somewhat toward base; palm oblique, nearly straight, with a row of three spines on outer margin around distal end; an oblique row of two or three spines on inner surface of hand near distal end of palm; several gnathopods with carpus narrowly triangular, not truncated at posterior inferior angle, posterior margin with about eight transverse rows of stout plumose setæ; lower margin with a few simple setæ; hand oblong, palm oblique, a row of three or four spines on both inner and outer surfaces of hand near distal end of palm; dorsal side of abdomen more or less protruding, especially in older specimens, at posterior end of third and fourth segments; fourth segment indented slightly near base; first two uropods with outer rami markedly shorter than inner; peduncle of first slender, longer than inner ramus, armed with about eight spines on inner margin and many more smaller spines on outer; both margins of both rami with numerous short spines; a cluster of large spines at tip of each ramus; peduncle of second uropods shorter than inner ramus, with five to seven spines on outer margin and about four on inner; rami much as in first pair, but with much fewer marginal spines; third uropods extending beyond second, rami flattened lanceolate, the inner somewhat longer and broader at base than outer one and about twice length of peduncle; both margins of both rami furnished with numerous spines and plumose setæ; telson cleft nearly to base, the lobes subacute.



*Pontogeneia inermis.* Grand Manan.

Nearly colorless, with scattered spots of purplish; antennæ with a few transverse purplish bars. Eyes reddish or reddish brown.

Length, 11 mm.

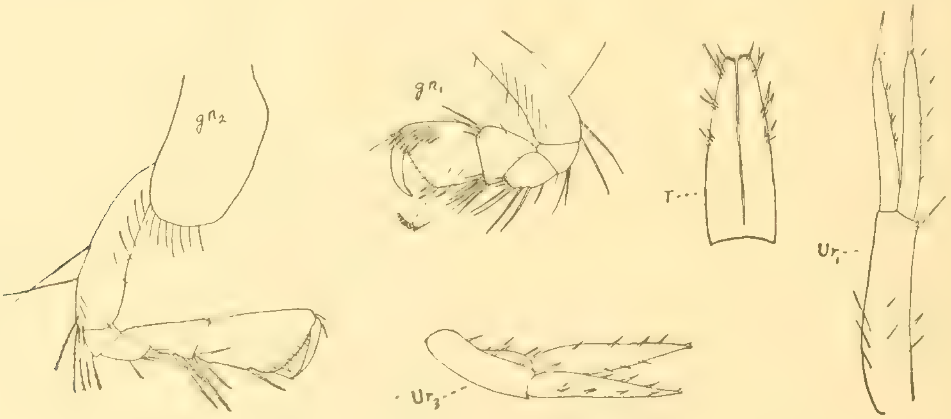
Vineyard Sound (Smith); Grand Manan (Stimpson); Halifax; Bay of Fundy to Greenland (Smith); Arctic Ocean; Norway (Sars).

Found commonly in tide pools and often taken at the surface. It is often associated with *Calliopius læviusculus.*

The antennæ of the males of this species are provided with a number of very large calceoli. These organs occur on the peduncles of both pairs of antennæ, but are absent in the flagella. In several specimens examined there were 5–7 calceoli on the lower side of the second joint of the peduncle of the first antennæ and four or five on the lower side of the third joint. On the second antennæ the calceoli are on the upper inner margin of the last two basal joints. In the specimens examined the penultimate basal joint carried 7–8 calceoli, and the last basal joint 6 or 7. I have found no calceoli upon the antennæ of the females. These organs are very large and conspicuous, and are in the shape of an urn with a very wide and flaring mouth. Each is situated upon a prominence to which it is united by a short stalk. Both the outer and inner surfaces of these organs are beautifully striated.

### **Dexamine thea** Boeck.

Head produced into a small rostral projection; eyes nearly round, margin of the head in front of each produced into an acute angular process; first antennæ over half length of body; first joint of peduncle rather stout, nearly two-thirds length of slender second joint, which is about three times the length of third; flagellum slender, with 12–16 elongated segments; second antennæ (at least in female) much shorter than first; last two joints of slender peduncle of subequal length; flagellum not much (if any) exceeding peduncle, and composed of 5–9 elongated joints; mandibles much as in *D. spinosa;* under lip with very small inner lobes; first maxillæ with inner plate very small, subovate, and terminated with a single seta; outer plate with about eleven dentate and furcate terminal spines; palp unarticulate, distally widened and furnished with several terminal setæ, the inner margin devoid of setæ or possessing a single one; second maxillæ as in *D. spinosa;* maxillipeds with inner plate short and rather broad, the transverse distal margin furnished with about six large setæ; outer plate very large, overlapping the palps, inner margin minutely denticulated toward distal end, the distal half (or less) of inner side furnished with about six stout spines which increase in length and become set farther from the edge toward the tip; palp scarcely exceeding tip of outer plate; dactylus absent; first four coxal plates well developed, much deeper than broad, but not much deeper than their segments; lower margins setose; first gnathopods rather stouter but shorter than second; carpus short, subtriangular; hand rather broader than carpus; palm oblique, finely pectinated, rounded distal end armed with two stout spines; second gnathopods with carpus narrowly triangular, furnished with a tuft of large setæ at lower posterior angle and another near middle of posterior margin; hand regularly widening toward distal end; palm oblique, finely pectinated rounded posterior angle armed with two stout spines; hand and carpus taken together forming a narrow, elongated triangle; peræopods very spiny, dactyls narrow, over half the length of propodi; basal joint of penultimate pair much expanded; posterior margin serrated and strongly bulging backward; basal joint of last pair not expanded, linear; first four segments of abdomen each larger than any of the thoracic segments, and armed dorsally with a strong posterior spine; postero-lateral angle of third segment produced and acute; second uropods much shorter than first or third, rami like those of first, with an elongated terminal spine and several lateral spines; terminal uropods extending a little beyond first, the rami flattened, subequal, lanceolate, devoid of a terminal spine, and nearly twice the length of peduncle; telson much elongated, extending nearly to tip of posterior uropods, cleft nearly to base, lobes denticulated at tip and furnished with about three tufts of spines near lateral margins and one or more spines at distal end.



*Dexamine thea.* Woods Hole, Mass.

Length of specimens examined, scarcely 3 mm. Adult specimens examined by Sars measured 4 mm.

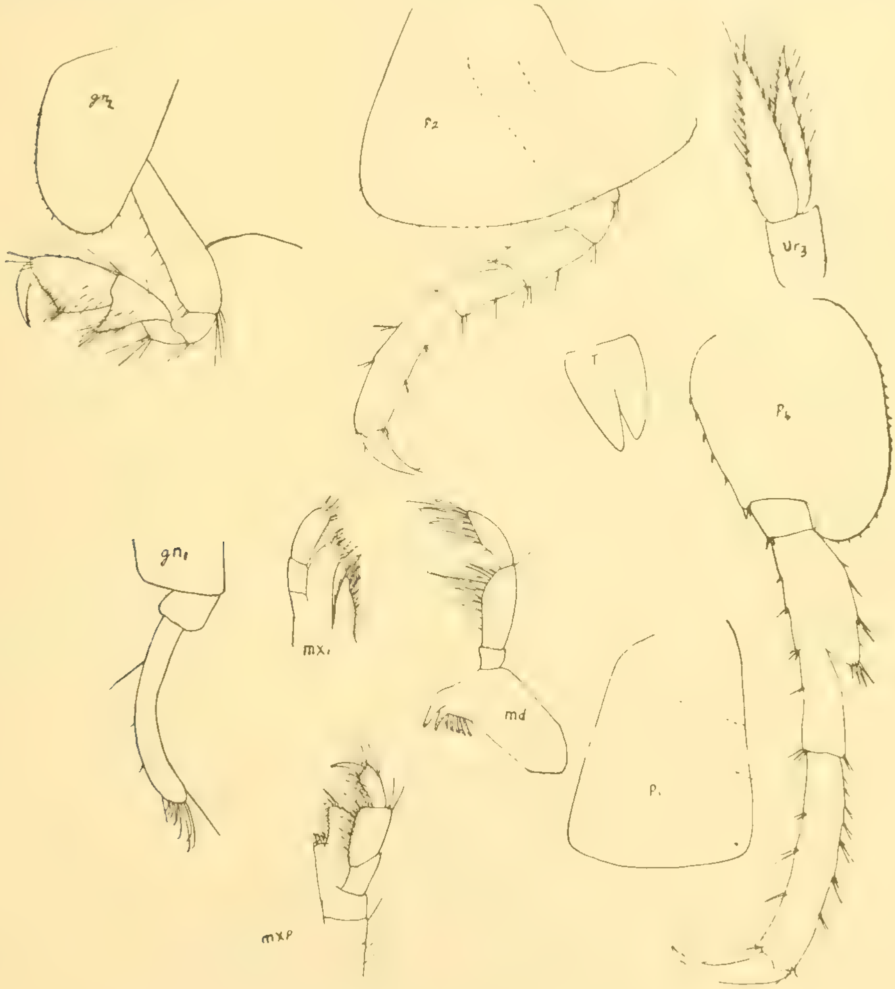
Norway (Sars); British Isles; France; Woods Hole, Mass.

Described from several specimens taken at Woods Hole, June 25, 1900. The females were carrying eggs.

This species is closely allied to *D. spinosa*, the type of the genus, but is of much smaller size and has the basal joint of the posterior peræopods very much narrower, much fewer joints in the antennae, smaller and differently shaped eyes, and much fewer spines on the inner margin of the outer plate of the maxillipeds. The hand of the first gnathopods is a little stouter and has the palm somewhat less oblique than in the specimen of *thea* figured in Sars's Crustacea of Norway, but in every other feature the Woods Hole specimens agree perfectly with Sars's description and figures.

### **Batea secunda** Holmes, new species.

Female: Head with a rather prominent narrow rostrum; eyes well developed; first antennæ nearly as long as second, first joint of peduncle much stouter and a little longer than second; third joint small, less than half the length of second; flagellum consisting of about 18 elongate segments which are furnished with well-developed setæ and, on alternate members, with olfactory clubs; second antennæ nearly half as long as body, last two joints of peduncle of nearly equal length; peduncle about as stout as that of first antennæ and composed of elongate joints; mandibles with a well-developed molar



*Batea secunda*. Woods Hole, Mass.

tubercle, dentate primary and secondary cutting plates, and a spine row composed of five stout, irregularly serrate spines; palp with third joint about three-fourths the length of second; last two joints strongly setose on inner margin; lower lip with rather small inner lobes; first maxillæ with inner plate narrow, furnished with three plumose setæ—one at tip and two near distal end of ciliated inner margin; palp two-jointed, distal extremity nearly transverse and armed with several strong spines and setæ; maxillipeds with inner plates well developed, extending a little beyond first joint of palp, distal end broadly rounded, furnished with several short plumose setæ and three short stout teeth near the middle line; outer plate about equaling second joint of palp, furnished with a few odontoid processes on distal part of inner margin and two or three stout plumose setæ at distal end; terminal joint of palp claw-like; first gnathopods consisting of rudiments of coxal plate and basal joint, former very small, latter curved, distally rounded, and furnished with several curved setæ around tip; coxal plates of three following appendages well developed and about as deep as their segments; first gnathopods rather slender; carpus with a large, triangular posterior lobe; hand with palm oblique, only slightly curved and minutely denticulated; dactyl with four spinous projections on inner margin behind tip; second peræopods with coxal plate broader than deep and deeply excavated at upper posterior angle; the three posterior peræopods increasing successively in length, basal joints broad, last pair considerably longer than preceding; claws of all the pairs large, strongly curved, and having a small seta near distal end of inner margin; the posterior margin of third abdominal segment with several upturned teeth above the rounded postero-lateral angles; first two pairs of uropods with rami styliform, outer ramus considerably shorter than inner; second uropods not extending nearly so far backward as first or third; third uropods with rami flattened, lanceolate, over twice the length of peduncle, margins of both armed with numerous short spines and plumose setæ; telson deeply cleft.

Length, 5 mm. Type No. 29244, U. S. Nat. Mus.

Several specimens were taken near Woods Hole during the summer of 1900. Some were dredged by the *Fish Hawk* in about 25 fathoms, and others were obtained off Nobska, at a depth of about 6 fathoms. The body and coxal plates in the living specimens were marked with blue or purplish pigment spots, formed by small clusters of hexagonal pigmented cells of the hypodermis. Sometimes the blue or purple color of these spots is replaced by a reddish brown, and in some specimens neither kind of spots occurs. There are also branched pigment cells on the body and appendages, which are dark in transmitted light, but silvery green in reflected light. The flagella of both pairs of antennæ are blue or purplish and the peduncles may contain branched pigment cells. The eyes are brownish. When placed in a dish of sea water the animals swim for only a short distance and then curl up and drop to the bottom.

The genus *Batea* was first established by Fritz Müller to contain a species found on the coast of Brazil (See Ann. and Mag. Nat. Hist. (3), vol. 15, p. 276, pl. x, 1865). The genus has not, up to this time, been met with north of the equator. It differs from all the other genera of the Gammaridea in the rudimentary character of the first gnathopods which in both the type species, *B. catharinensis* and the present one, consist of only the coxal and basal joints. Our species agrees quite closely with the one described by Müller, but has the coxal joint of the first gnathopods much smaller and fewer tooth-like processes on the inner margin of the outer plates of the maxillipeds. As in *catharinensis*, the eyes are larger and the antennæ longer in the male than in the female, and the first and second peræopods are furnished with long plumose setæ only in the male sex. In one male specimen in my collection the second antennæ exceed the length of the body.

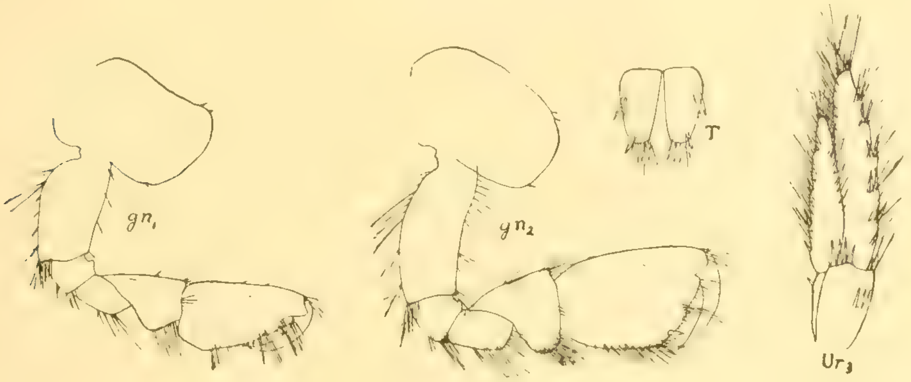
### **Gammarus locusta** (Linnæus).

*Gammarus ornatus* Edwards, Ann. Sci. Nat. t. xx, 1830, p. 367, pl. 10, figs. 1–10.

Body rather slender and compressed; eyes elongated, reniform, nearly reaching anterior margin of short lateral lobes of head; first antennæ a little longer and more slender than second and often (generally in females) shorter than half the length of body, the first joint a little longer than the second, which is twice the length of the third; secondary flagellum longer than second joint of peduncle and about 8-jointed; peduncle of second antennæ stout, the last two joints of subequal length; flagellum shorter than peduncle; first gnathopods of male with hand elongated (much longer than carpus), tapering from near the base, posterior margin continuous with palm, which is somewhat uneven, armed with a stout spine near the middle and a large spine with a row of several smaller ones above it at distal end; second gnathopods of male with hand much larger than in first, about twice length of carpus, subquadrate in outline; palms somewhat oblique and uneven, sharply marked off from the posterior margin, armed with a stout spine near middle and a large spine followed by several smaller ones near distal end; in the female the gnathopods are smaller than in the male and more nearly equal in size and shape; in the first pair the hand is not so narrow as in the male; hand of second pair resembles in shape that of male, palm less oblique than in first gnathopods; postero-lateral angles of second and third abdominal segments produced and acute, the margin above the angles generally furnished with short setæ; the three posterior segments with a median projection bearing a fascicle of spinules and a lateral fascicle on either side; last pair of uropods with both rami stout, inner nearly as long as first joint of outer; inner margin armed with about four stout spines; outer margin of outer uropods armed with about six groups of stout spines; telson with a group of two or three spines near base and three on apical margin, with another spine near the latter close to outer margin.

Color, olive brown to reddish brown, the margins of the segments colored a little more deeply than the other parts. Above the bases of the pleopods and first pair of uropods is a red, orange, or pink spot, produced by an aggregation of globules. Some of the globules are highly colored, while others are nearly or quite colorless. There is usually also a long patch of colored globules along the intestine.

Length, about 25 mm. Arctic specimens, according to Sars, attain a length of 48 mm.



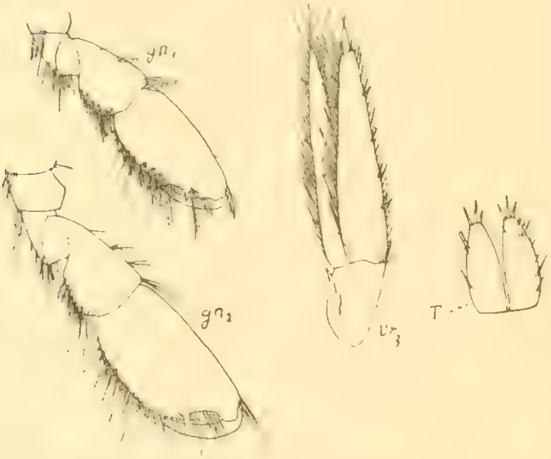
*Gammarus locusta*, male. Woods Hole, Mass.

The distribution of this species is very extensive, reaching throughout practically the whole of the circum-boreal region. On the eastern side of the Atlantic it extends into the Mediterranean Sea, and on the western side all along the New England coast and probably considerably further south. In the Pacific Ocean it extends from Bering Strait down the coasts, both of Asia and North America, for a considerable distance. This is the species of amphipod decidedly most often met with in collections from New England. It is abundant near the shore, but ranges into a depth of over 50 fathoms.

### **Gammarus annulatus** Smith.

*Gammarus natator* Smith, Rept. U. S. Fish Com. 1871–2, p. 558.

Eyes more or less reniform, broader than in *locusta;* antennæ often not more than one-third the length of body; first pair shorter than second, with second joint of peduncle only a little shorter than first and the third half the length of second; secondary flagellum nearly half the length of primary, peduncle of the second antennæ longer than flagellum, the last joint a little longer than preceding one; both pairs of antennæ with very long, fine, plumose hairs; first four pairs of coxal plates very deep, the lower margins of anterior three fringed with long hairs; first gnathopods in the male with hand narrowly oval, palm uneven, very oblique and continuous with posterior margin of hand, armed near the center with a stout spine, a pair of stout spines near distal end, above which is a double row of smaller blunt spines; hand of second gnathopods of male oblong, broader than that of first pair, with palm less oblique, concave in the center where the large spine is situated, and armed with a double row of spines at the distal end, the two rows being unequal in size and in number of spines; in the female the hands of both gnathopods are less stout than in the male, and are nearly equal in size and similar in shape. The palm in the first pair is, however, more oblique than in the second, and in both pairs the palms are more even than in the male sex and have laminate edges marked with fine vertical lines; peræopods slender, first and second pairs armed with only a very few weak spines but furnished with long slender hairs, which are especially abundant on posterior margins of carpus and merus; last three pairs with fascicles of spines; postero-lateral angles of second and third abdominal segments produced and acute; fifth and sixth abdominal segments with both median and lateral fascicles of spines; third segment with only a median fascicle; last uropods elongated, rami narrowly lanceolate, the margins furnished with long, plumose hairs; outer margin of outer ramus with several spines, the terminal article narrow and tapering to an acute tip; inner ramus equaling or exceeding end of first joint of outer, both margins armed with a few spines; telson with a variable number of spines near outer margin and several at the tip.



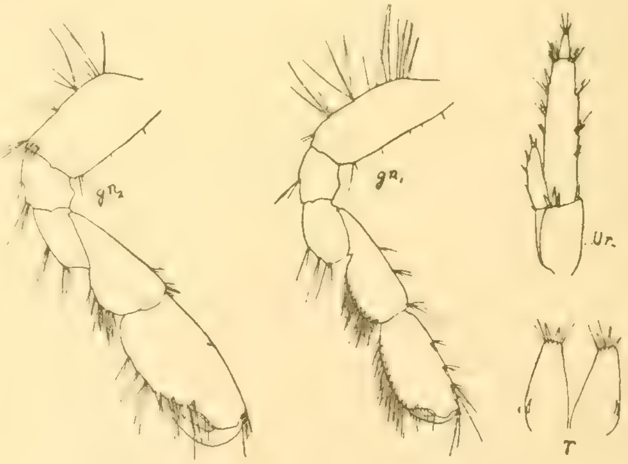
*Gammarus annulatus*, male. Woods Hole, Mass.

Length, 15 mm. Abundant in Vineyard Sound; Gloucester. This species of *Gammarus* is peculiar on account of its habitat at the surface, where it is often taken in great numbers.

Professor Smith has kindly sent me the types of his *Gammarus annulatus*. They prove to be the same species as the one he has described as *Gammarus natator*.

### Gammarus marinus Leach.

Body slender; lateral lobe with a rather deep emargination below; eyes reniform; first antennæ about half as long as body; second basal joint a little shorter than first, but twice the length of third; flagellum long and slender; secondary flagellum about 7-jointed and scarcely half as long as peduncle; second antennæ shorter than first; last two joints of peduncle of subequal length, flagellum longer than peduncle; first four coxal plates not large, the fourth deeper than broad; first gnathopods in the male somewhat stouter and larger than the second; carpus about three-fourths the length of hand; hand narrowly oval; palm very oblique, continuous, with posterior margin a little concave in the middle, where there is a stout spine on the outer side which is the first of a row of three spines, the last one of which is near distal end of palm; second gnathopods of the male with carpus a little longer than hand; osterior margin with 10–12 short tranverse rows of long setæ; hand subrectangular, about twice as long as wide, posterior margin densely clothed with long setæ arranged in about 13 transverse rows, palm oblique, concave in the middle; first gnathopods of the female nearly as large as those of the male and resembling them in form; first pair stouter than second, hand subquadrate, broader than in



*Gammarus marinus*, male. Woods Hole, Mass.

the male; palm oblique, but not nearly so much so as in the male, and devoid of median concavity, being gently and evenly convex. In the second gnathopods the carpus is both longer and broader than the hand, which is much like that of the male in shape, but is more nearly rectangular, with palm almost transverse and gently and evenly convex; postero-lateral angles of the second and third abdominal segments not produced nor sharp-pointed; three fascicles of spines on each of the three posterior abdominal segments, the spines on each segment being arranged in two rows which converge anteriorly; terminal uropods with outer ramus large, both margins armed with three to five fascicles of stout spines; inner ramus small, often less than one-third the length of outer; telson with three spines at the tip of each half and one on a pair of spines close to outer margin near base.

Length, 15 mm.

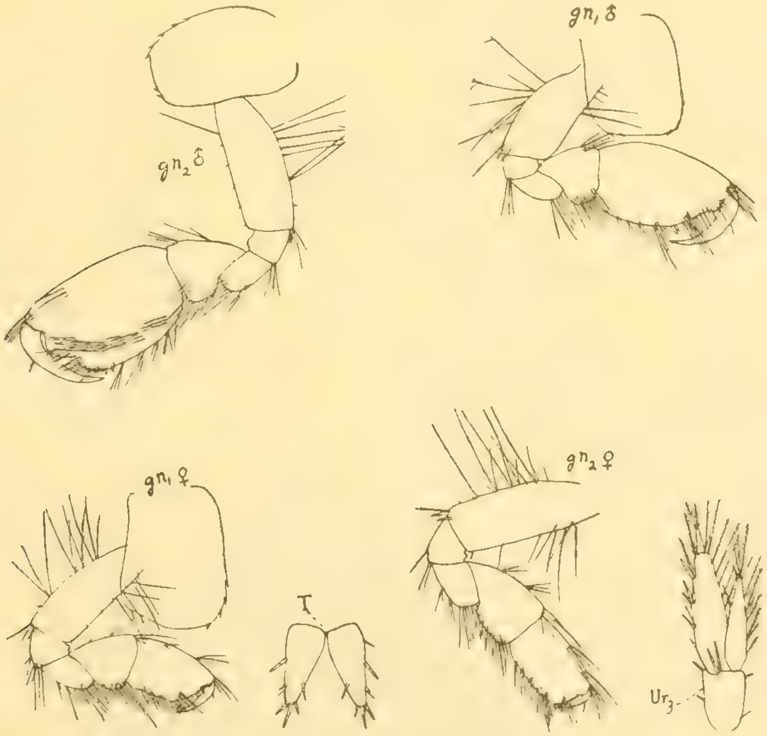
This species is found under stones at low tide. It has been taken at New Haven, various places in Vineyard Sound and Buzzards Bay, Newport, and Woods Hole.

A comparison of specimens from New England with specimens of *Gammarus marinus* Leach, from North Devon, England, shows a similarity in all essential respects between forms from these two remote localities. In specimens from our coast the second gnathopod is a little smaller relatively to the first than in the specimens examined from England.

### **Carinogammarus mucronatus** (Say).

*Gammarus mucronatus* Say, Jour. Acad. Nat. Sci. Phila., Vol. I, 1818, p. 376.

Eyes reniform; first antennæ a little longer than second; first joint of peduncle longer than second; third joint about three-fifths the length of preceding one; flagellum about twice the length of peduncle; secondary flagellum not half the length of peduncle and composed of three or four joints; second antennæ with flagellum about equal to peduncle and composed of about ten oblong joints; first four coxal plates deep; the first one oblong, of similar shape to the second and third; fourth deeper than



*Carinogammarus mucronatus.* Great Egg Harbor, N. J.

wide; first gnathopods in male stout, smaller than second; carpus not quite half as long as hand; hand narrowly oval; palm uneven, very oblique, continuous with posterior margin; hand of second pair oblong, with the two sides nearly parallel; palm oblique, with a laminate cross-striated edge which is concave near the middle, a cluster of spines around the distal end. In the female the gnathopods are of nearly equal size; hand of first pair subquadrate, with anterior margin quite convex; palm oblique and quite evenly convex, with a few slender spines around posterior end; hand of second gnathopods oblong, nearly rectangular; palm nearly transverse, evenly convex, with a few slender spines around distal end, where it becomes more sharply curved; posterior margin of first three abdominal segments produced backward in the mid-dorsal line into a prominent acute tooth; last three segments with fascicles of spines; telson with three terminal and a few lateral spines on each division.

General color olive green. A reddish spot above bases of first four abdominal appendages formed as in *Gammarus locusta.*

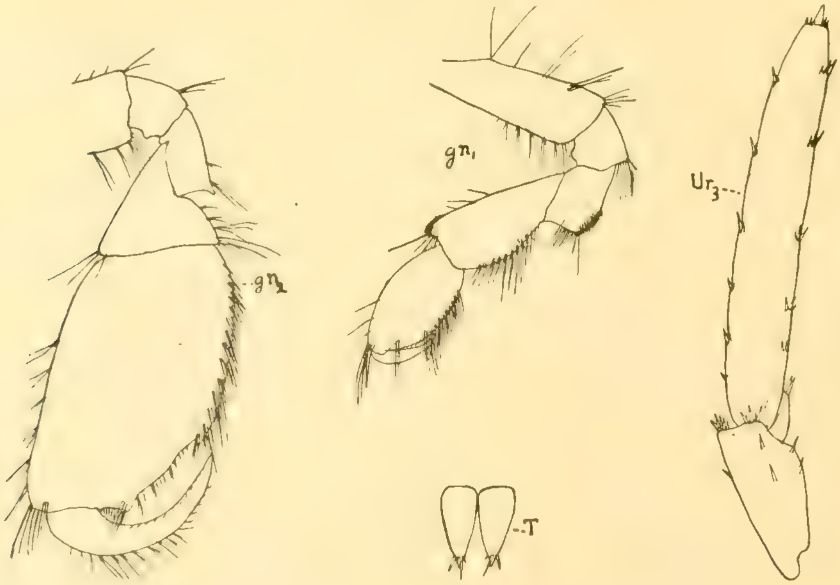
Length, 6 mm.

Cape Cod to Florida; Alabama (Herrick); often in brackish water.

### **Melita dentata** (Kröyer).

*Gammarus purpuratus* Stimpson, Marine Invert. Grand Manan, p. 55, 1853.

Body much compressed; eyes round or oval; first antennæ much longer than second; second joint of peduncle longer than first and about four times the length of third; secondary flagellum about five-jointed; peduncle of second antennæ long and slender; last joint a little shorter than preceding one; flagellum shorter than peduncle; first four coxal plates deeper than their segments, the fourth deeper than wide; first three with a small tooth at postero inferior angle; first gnathopods of male with hand and carpus of subequal size, a dense tuft of very short setæ on posterior side of merus and anterior side of carpus near distal end; hand oval; palm quite evenly convex, very oblique and continuous, with posterior margin of hand above it, which it about equals in length; second gnathopods of the male with a very large, strong hand, palm very oblique, with a large triangular tooth near lower end and terminated above by a large spine tooth, the space between the two teeth convex in the middle and armed with short spines. In the female the first gnathopods closely resemble those of the male; carpus longer relatively than in the other sex and hand of similar shape though smaller in size;



*Melita dentata*, male. Narragansett Bay.

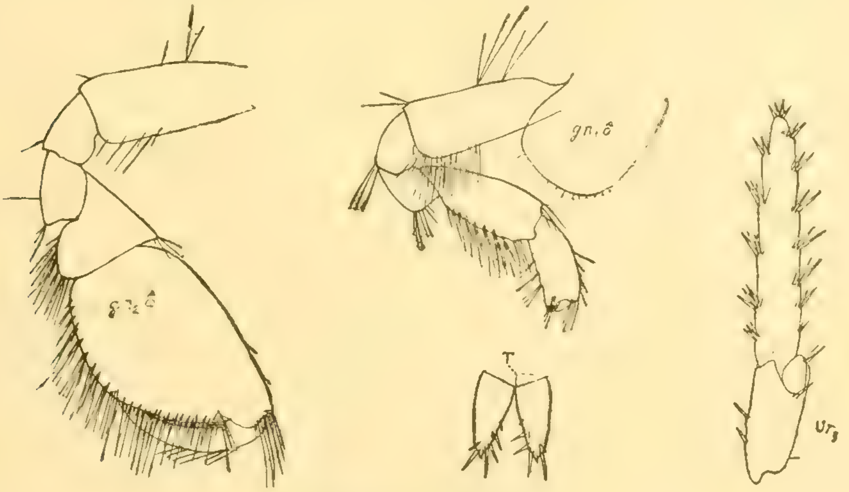
no prominent tooth near lower side of palm, margin of palm serrated and defined above by a spine tooth as in the male; peræopods slender and elongate, with basal joints large, oblong, and serrated on posterior margin; posterior margins of abdominal segments produced into teeth, the median one of which is the largest, the median tooth on the fourth segment being largest of all; posterior uropods elongated, outer ramus with sides nearly parallel to near the tip and armed on inner side with four or five and on the outer with five or six fascicles of short spines whose length is less than the diameter of the ramus; the median one of the group of terminal spines is much stouter than the others; inner ramus minute; each lobe of telson terminating in an acute point, on inner side of which is a large and a small spine and on outer a spine or seta.

Length, 16 mm.

This species is extensively distributed in the Arctic Ocean, extending down the eastern side of the Atlantic along a large portion of the coast of Norway and on the western side to Buzzards Bay, and perhaps farther. Several specimens were dredged by the *Fish Hawk* in Rhode Island waters. In some specimens the spines on the posterior uropods are larger than in the one figured. The depth range of this species, according to Sars, is from 10 to 15 fathoms.

### **Melita nitida** Smith.

Body slender, compressed; eyes small and round; first antennæ two-thirds the length of body or more; second joint of peduncle longer than first and nearly twice the length of third; flagellum longer than peduncle; secondary flagellum three-jointed in adults, not longer than third joint of peduncle; second antennæ shorter than first, last joint of peduncle nearly as long as preceding joint; flagellum shorter than peduncle, joints furnished with whorls of long setæ, like those on last joint of peduncle; first four coxal plates deeper than their segments, first three oblong; first gnathopods much alike in the two sexes; carpus longer and broader than the hand, which is oblong, somewhat curved backward; palm about one-third the length of the nearly transverse distal margin of the hand; finger short, much curved, very thick at base, and articulated in the middle of distal margin of hand; hand of second gnathopods in male large, oval, palm evenly convex, about as long as posterior margin above it, with which it forms an almost continuous curve; tip of finger closing against inner side of hand; hand of second gnathopods of female much like that of male, but smaller in size; basal joints of last three peræopods large, oblong, armed with short spines in front and serrated behind; posterior margins of abdominal segments not dentate nor produced; fifth segment with several spines on posterior margin on either side of mid-dorsal line; last uropods long; inner ramus minute, situated in a sinus of peduncle; outer ramus of much the same form as in the preceding species and armed on either side



*Melita nitida.* Woods Hole.

with several fascicles of strong spines which are relatively larger than those of *dentata;* median spine of terminal cluster not unusually large; telson with tip of lobes triangular, acute; a few spines around tip and on distal part of inner margin.

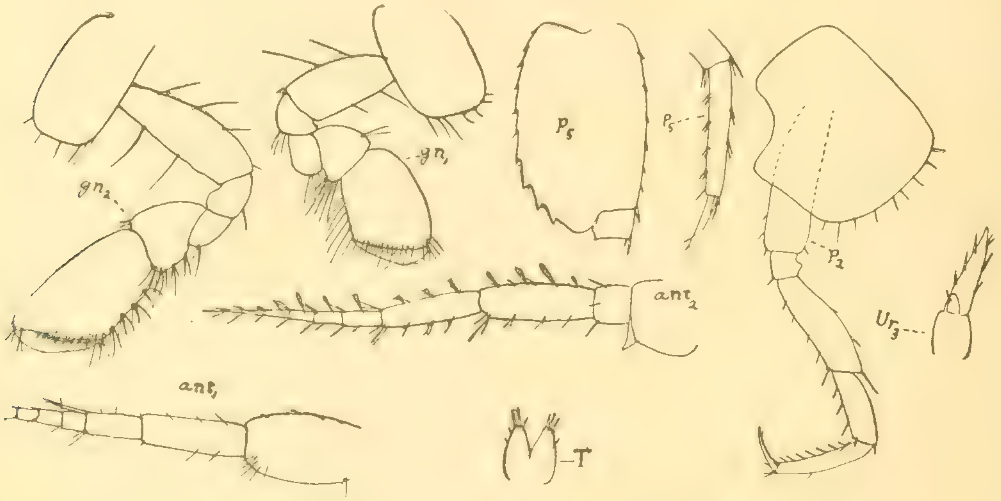
General color of the body and appendages grayish, the color not confined to pigment cells, but scattered in the form of minute pigment granules in the cells below the integument; body and legs crossed by bands of a somewhat darker color; a red spot above on anterior portion of head; eyes black, with a slight tinge of red.

Length, 10 mm.

New Jersey to Cape Cod (Smith); Woods Hole, under rocks near the breakwater.

### **Melita parvimana** Holmes, new species

Eyes oblong; lateral angles of head rounded; first antennæ much longer than second, first and second joints of peduncle of subequal length, each about twice the length of third; flagellum about twice the length of peduncle; secondary flagellum not longer than last joint of peduncle and consisting of two joints; second antennæ with last joint of peduncle about three-fourths the length of preceding one; flagellum shorter than peduncle and consisting of six segments; last two joints of peduncle and first few joints of flagellum carrying large clavate appendages (olfactory clubs?) near upper margin, outer surface of these clubs very regularly annulated; first three coxal plates much deeper than wide and setose on the lower margin; fourth pair nearly as wide as deep; first gnathopods rather short and stout; carpus as wide as long, its rounded posterior lobe armed with about seven long setose spines; hand broad, subquadrate; palm oblique and armed with numerous short, stout, notched spines; posterior margin nearly straight and furnished with numerous setose spines; second gnathopods longer but not much stouter than first; carpus somewhat longer than wide; hand oblong, slightly widening distally; palm very oblique, armed with numerous stout notched spines; first and second peræopods slender, merus much longer than carpus; dactyl nearly two-thirds the length of propodus and furnished with one or more setæ near distal end of lower margin; the three posterior peræopods long and slender; carpus longer than merus but shorter than propodus; dactyls slender, nearly straight and over half the length of propodi; lower margin with one or more setæ near distal end; posterior margin of basal joint of last peræopods more coarsely serrated than in preceding ones, especially toward the lower side; abdomen smooth above and devoid of teeth or spines on posterior margins of segments; postero-lateral angles of first three segments produced into an acute tooth; a few spines near lower margins of second and third segments; posterior uropods rather small; inner ramus minute and



*Melita parvimana.* Newport, R. I. Only the proximal portion of the first antenna is shown.

scale-like, subovate, outer ramus acute, single-jointed, and scarcely twice the length of peduncle; telson small and cleft to a little beyond the middle.

Length, 12 mm. Type No. 29240, U. S. Nat. Mus.

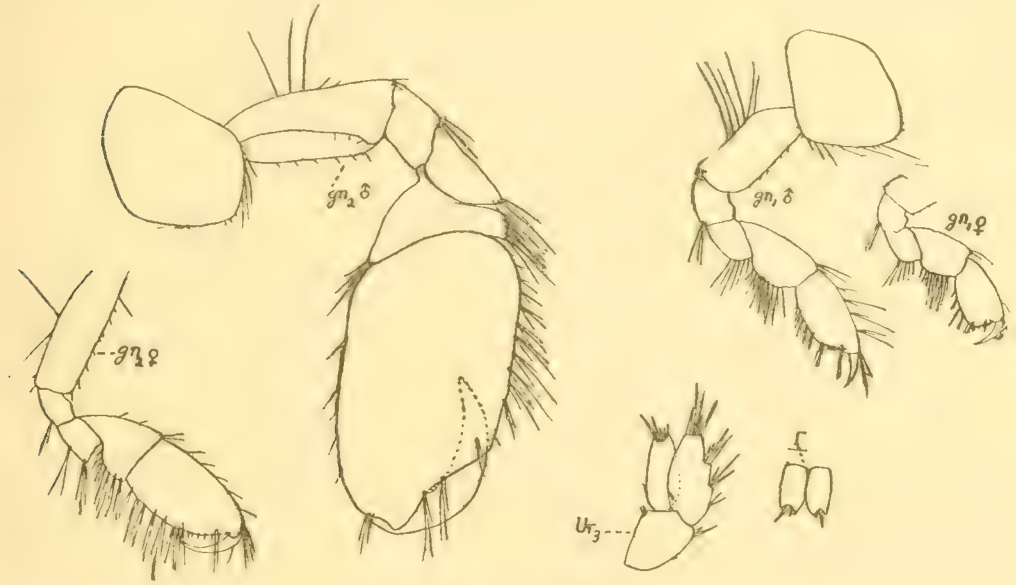
Described from a single specimen taken by S. D. Judd, at Newport, R. I.

This species differs from most of the species of *Melita* in having smaller second gnathopods, smaller terminal uropods, and more elongated propodi on the peraeopods, but possesses no characters which exclude it from the genus.

### **Elasmopus lævis** (Smith).

*Mæra lævis* Smith, Rept. U. S. Fish Com. 1871–2, p. 559.

Eyes nearly round; first antennæ rather stout and about two-thirds the length of body; third joint of peduncle about two-thirds the length of second, which is subequal to the first; flagellum about as long as peduncle, segments rather short; secondary flagellum not half as long as last joint of peduncle and consisting of two oblong joints and a minute very short terminal joint; second antennæ scarcely longer than peduncle of first pair and slender, flagellum shorter than peduncle and consisting of about eight joints. First four coxal plates not deeper than their segments; fourth about as broad as deep. First gnathopods in male with hand oblong, subequal to carpus; palm quite oblique and evenly convex. Second gnathopods of male very large, carpus scarcely one-fourth the length of hand; much broader than long, with a narrow posterior lobe; hand oblong, the opposite sides nearly parallel, palm oblique, smooth; a row of four or five spines near base of finger on a ridge just within margin of palm; the stout finger closes not against palm but into an excavation on inner side of hand; a conical tooth at upper end of this excavation. Hand in first gnathopods of female much like that of the male, but the palm nearly transverse. Second gnathopods much smaller than in the male, oblong in shape, somewhat resembling first gnathopods of the male; palm oblique, armed with two rows of spines along its entire length and with a pair of larger spines at distal end; finger more nearly straight than in the male; more evenly tapering and closing against the palm. Merus and carpus much expanded in last two peræopods of male; terminal uropods projecting beyond others, rami short, broad, inner one narrower than outer and a little shorter, with a small spine near base of inner margin; outer ramus with three fascicles of stout spines on outer margin; tips of both rami truncated and armed with numerous spines; telson with lobes oblong, notched at the tip, where there is one or two spines.



*Elasmopus lævis.* Woods Hole, Mass.

Body olive brown to grayish, marked with numerous small rounded lighter colored spots and a series of larger light spots along mid-dorsal line. Pigment scattered as in *Melita nitida.* In specimens with much gray pigment the legs are barred with dark bands; in others these bands may be scarcely visible. The extreme tips of the basal joints of both antennæ are light colored; eyes black.

Length, 10 mm.

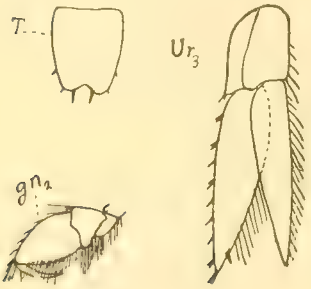
New Jersey; Long Island Sound; Vineyard Sound (Smith); Provincetown (Rathbun); Woods Hole, Mass.

Found under rocks and among seaweed at low tide.

### **Gammarellus angulosus** (Rathke).

*Amathilla angulosa* Boeck, Amphip. boreal. arct., p. 137, 1870.

Head with rather large oblong or reniform eyes; lateral angles rounded; rostrum very short; antennæ rather stout, subequal, scarcely half the length of body; peduncle of first pair with joints decreasing successively in length and width; flagellum longer than peduncle; secondary flagellum four-jointed; second antennæ with flagellum larger than peduncle, segments, like those of first pair, furnished with a terminal circlet of sensory clubs; body with a dorsal carina which extends from head to near end of abdomen, not so high as in *G. homari* and not extended as a posterior projection from the end of each segment; first four coxal plates rather small, not so deep as their segments, quadrate in form and increasing successively in size from first to fourth; gnathopods, aside from coxal plates, of almost exactly same form and size; hand narrowly ovate; palm setose and armed with four or five fascicles of strong spines; three posterior peræopods of nearly equal length; dactyls of all pairs similar and furnished with a single prominent seta near the distal end of lower side; postero-lateral angles of first three abdominal segments rounded; terminal uropods with rami flattened, lanceolate, broader than in *G. homari*, the margins furnished with spines and plumose setæ; outer ramus a little larger than inner one; telson nearly as broad as long and slightly emarginate at tip.



*Gammarellus angulosus*, female. After Sars.

Length, 10 mm.

Norway (Sars); British Isles; France; Nahant; Casco Bay, Me.

*G. angulosa* is closely allied to *G. homari*, but differs from it in being of smaller size, in having no posterior projections from the dorsal side of body segments, in having shorter and stouter antennæ, and in the shorter telson. *G. homari* has been reported from Grand Manan under the name of *Gammarus sabinii* by Stimpson. Another species, *Gammarus macrophthalmus*, is described by Stimpson from the same locality. It is said to be very closely allied to the preceding species (*G. sabinii*) in color and general appearance. The back, however, is carinated only at the abdomen, which readily distinguishes it. The appendicular branches of the superior antennæ are minute, and scarcely perceptible. Eyes very large, subreniform, near each other; epimera small; caudal stylets of first pair as large as those of second, both with their outer rami shorter and narrower than the inner ones; last pair with broad, lancet-shaped rami, shorter than in *G. sabinii.* Color sometimes bright crimson, but usually mottled red and flake white; very variable. Length 0.5 inch; of the inferior antennæ, which are longest, 0.2. Were it not that Stimpson states that in *macrophthalmus* the back is carinated only at the abdomen and describes the secondary flagellum of the first antennæ as "minute, and scarcely perceptible," I should be inclined to regard this species and *angulosa* as identical.

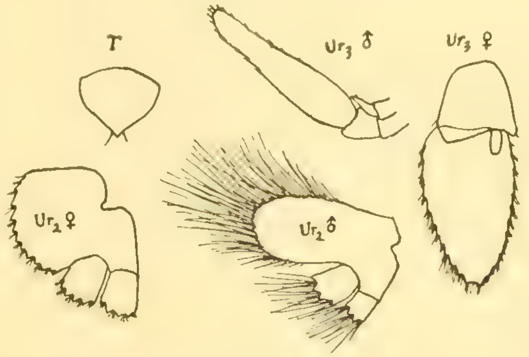
### **Chelura terebrans** Philippi.

Body robust, somewhat depressed; head tumid; antennæ shorter than half the length of thorax; second antennæ with flagellum consisting of a large oblong joint, setose on the edges, and one or two minute terminal joints; coxal plates small, diminishing in depth posteriorly; third abdominal segment with a median dorsal posteriorly directed spine-like projection, which is very large in the male; last three abdominal segments coalesced; uropods peculiarly modified for boring, the first pair lying under the abdomen and having a long peduncle with two short rami; second uropods subdorsal, peduncle with an immense dorsally projecting lobe, broad and coarsely serrated in the female, but oblong, serrated, and thickly setose on the margin in the male; rami short, quadrilateral, distally serrate; terminal uropods very large, inner ramus minute, outer narrowly oval in the female but narrow and much elongated in the male.

Length to tip of telson, 5-6 mm.

Extensively distributed along the coast of Europe; from Norway to the Mediterranean; east coast of the United States (Smith).

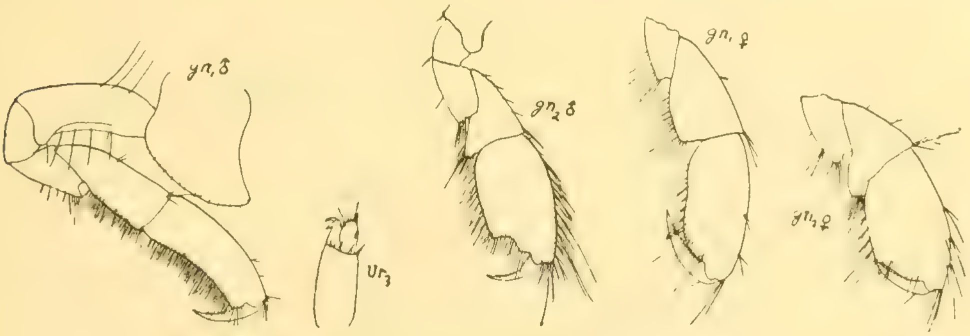
This species, like the isopod *Limnoria*, has the habit of boring in timber and is very destructive to piles and other submerged woodwork.



*Chelura terebrans.* After Sars. The third uropods of the male are drawn to a smaller scale than the other parts.

**Amphithoë longimana** Smith.

Body rather slender; eyes round and red in life; first antennæ slender, about as long as body; second basal segment longer than first, and nearly twice as long as third; second antennæ stouter than first, especially in the male, and somewhat shorter; peduncle much elongated, and about twice the length of the flagellum; first five coxal plates much deeper than their segments; the first strongly produced at anterior angle, and concave on superior free margin, the three following plates oblong; gnathopods in male well developed, first pair unusually elongated; carpus long and narrow; propodus three or more times as long as wide, as broad as carpus and about as long; palm short, transverse; dactyl large and projecting when closed, far beyond the palm; both carpus and propodus have the posterior margin thickly covered with rather short setæ; second gnathopods with carpus subtriangular, much shorter than propodus; propodus oblong, much wider than in first pair; palm oblique, concave, posterior angle prominent. Gnathopods in the female comparatively small; propodus of the first pair oblong, longer than carpus; palm oblique and rounded posteriorly, where it is armed with a strong spine; dactyl projecting beyond palm, but not nearly so far as in the male; in second gnathopods carpus produced posteriorly into a narrow, distally setose lobe; hand oblong, shorter and broader than in first pair; palm oblique, defined posteriorly by a slight projection and a strong spine; none of the angles of abdominal segments produced posteriorly; terminal uropods with rami of subequal length and not more than half as long as peduncle.



*Amphithoë longimana.* Woods Hole, Mass.

Color very variable, ranging from dark reddish to light green.

Length, 9 mm.

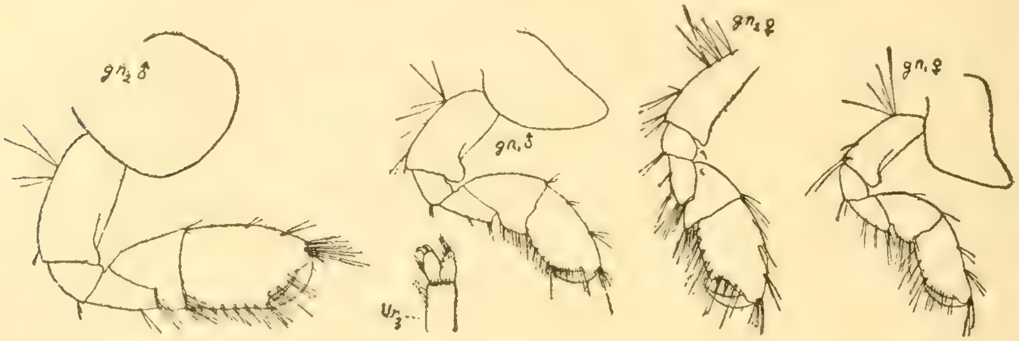
Woods Hole, Mass.; Vineyard Sound; Long Island Sound (Smith); New Jersey.

The habits, color variations, and general natural history of this species I have described at length in a previous paper (Biological Bulletin, vol. 1, 1901, pages 165-193).

### Amphithoë rubricata (Montagu).

*Amphithoë maculata* Stimpson, Marine Invert. Grand Manan, p. 53, 1853.
*Amphithoë valida* Smith, Rept. U. S. Fish Com. 1871–72, p. 563.

A stout, robust species; eyes rather small, circular to oval in outline; first antennæ sometimes exceeding half the length of body, especially in the female; second basal joint about as long as first and twice as long as third; flagellum generally longer than peduncle and slender. Second antennæ stout, especially in the male, in which they may nearly equal the first pair in length; flagellum short and thick, composed of few joints, often less than half the length of peduncle; coxal plates deeper than their segments, the first strongly produced at anterior angle, which is narrowly rounded; second coxal plate broad, produced, and very broadly rounded at anterior angle; first gnathopods in the male stout, basal joint broad and produced into a prominent lobe at inferior angle; hand oblong, palm oblique convex, posterior angle rounded and armed with a spine; second gnathopods with basal joint broad, inferior lobe relatively smaller and more acute than in first pair; hand rather stout, with a terminal tuft of plumose setæ; palm oblique, proximally convex and distally somewhat concave, posterior angle produced; in female, carpus of first gnathopods shorter than in male, and hand narrower but otherwise quite similar in form; hand of second gnathopods resembling that of male, but not so densely setose at the tip, and the posterior end of the palm has a strong spine; posterior angles of three anterior abdominal segments rounded; terminal uropods more than half the length of peduncle.



*Amphithoë rubricata.* Arichat Cape.

Color varying from green to reddish; generally a row of light-colored spots along mid-dorsal line, one spot to each segment.

Length, 20 mm.

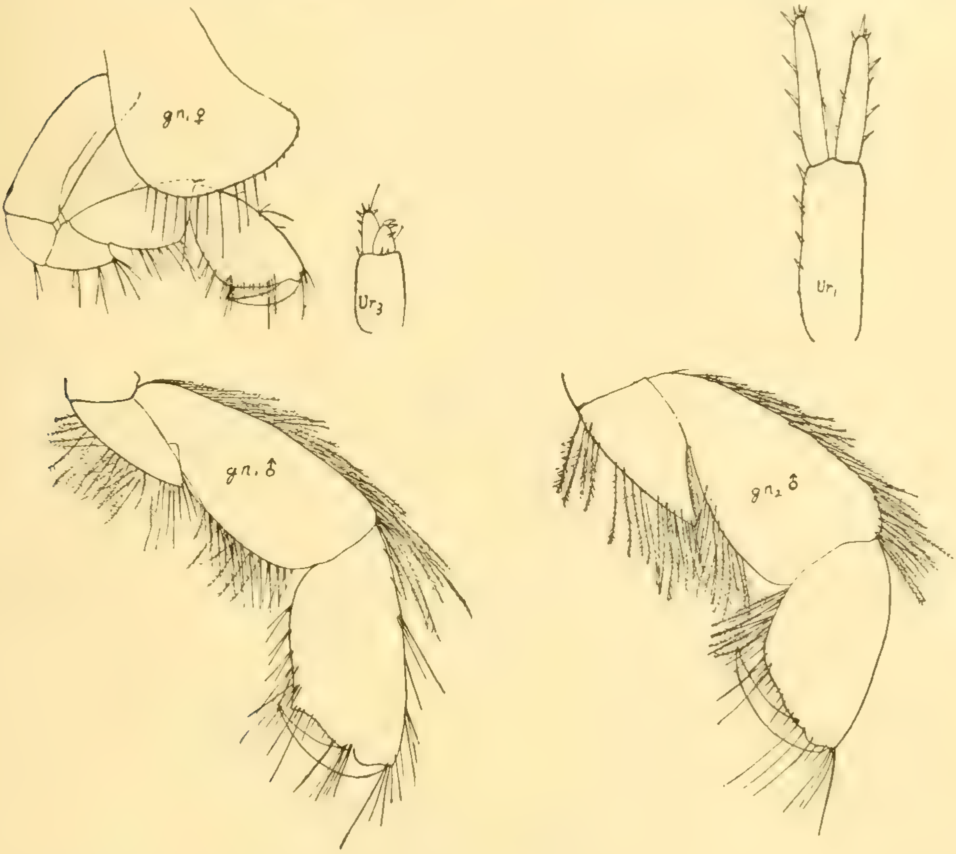
Found under rocks and amongst seaweed at low tide; specimens are often found in tubes covered with sand or bits of algæ. Whole coast of Norway (Sars); England; France; Azores; Labrador; Bay of Fundy; Grand Manan (Stimpson); Woods Hole; Newport, R. I.

I have compared American forms with specimens of this species from England. Specimens sent to the U. S. National Museum by Professor Smith under the name *Amphithoë valida*, and which I have examined, agree well with Professor Smith's description of that species, which is certainly identical with *A. rubricata.*

### Grubia compta (Smith).

*Amphithoë compta* Smith, Rept. U. S. Fish Com. 1871–72, p. 564.

Body more robust than in *Amphithoë longimana*, but less so than in *A. rubricata;* eyes round, red in life; first antennæ sometimes as long as body; second basal joint a little longer than first, and about three times as long as third; flagellum slender, elongated; a small two-jointed secondary flagellum not longer than last joint of peduncle; second antennæ rather slender, nearly as long as first; flagellum slender and elongate; anterior coxal plates oblong, much deeper than their segments, anterior pair not produced forward so much as in preceding species; gnathopods in the male much elongated and with both margins furnished with long plumose hairs; first pair about as large as second; merus produced downward into a large triangular process, which is excavated anteriorly to receive carpus; carpus considerably larger and slightly broader than hand; hand oval; palm oblique, nearly straight, rounded at posterior end, where it is armed with a strong spine; second gnathopod merus produced downward into a jointed process, carpus narrower than in first pair, propodus oblong; palm oblique, sinuous, with a projecting posterior angle, but no terminal spine; gnathopods in the female of nearly equal size, of similar form, and very small in comparison with those of male; merus of both pairs produced, but not so much so as in the male; carpus and propodus in both not very unequal in size; propodus narrowed at proximal end and widened distally; palm oblique, rounded posteriorly, where it is armed with a spine; postero-lateral angles of second and third abdominal segments with a triangular acute tooth; first pair of uropods with a large spine on distal end of peduncle, which is about two-fifths the length of the rami; terminal uropods with rami unequal, outer or shorter one scarcely half the length of peduncle; inner ramus with spines at the tip and on inner margin.



*Grubia compta.* Woods Hole, Mass.

Color variable, much as in *Amphithoë longimana.*

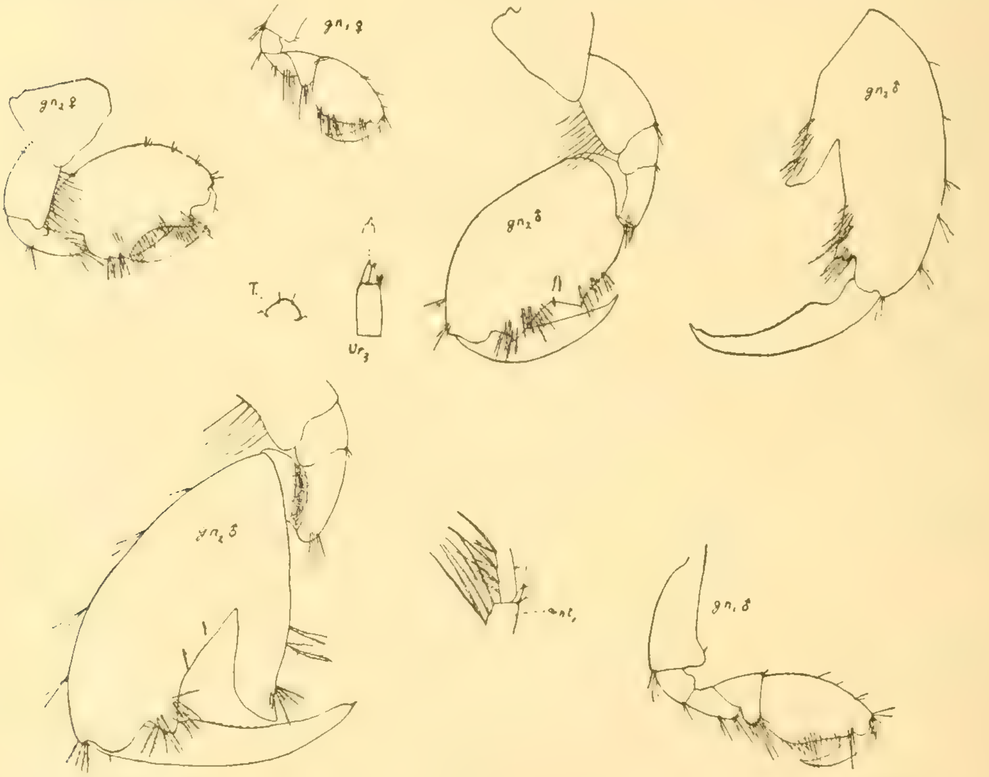
Length, 12 mm.

North Carolina to Cape Cod (Smith); Woods Hole, common in the Eel Pond.

Found among algæ and eel grass.

### **Jassa marmorata** Holmes, new species.

Closely allied to *J. pulchella;* rostrum small and broadly triangular; eyes round, on prominent lateral lobes; both pairs of antennæ stout, first shorter than second, its first basal joint much shorter than second, which is a little longer than third; flagellum not much longer than last joint of peduncle and composed of five or six joints, of which the first may be as long as all the rest; secondary flagellum minute one-jointed; second antennæ very stout, last joint of peduncle a little longer than preceding one; flagellum short, about three-fifths the length of last joint of peduncle, and composed of two or three joints, of which the first is much the longest; lower margins of both pairs of antennæ clothed with long setæ; first gnathopods in both sexes with hand ovate, broader in female than in male; palm very oblique, with a row of three spines around its upper end; second gnathopods with hand enormously developed and produced at upper end of palm into a long, narrow process; a triangular tooth near lower end of palm; second gnathopods in the female much smaller than in the male, the hand stout, oval in general outline, anterior margin very convex; palm concave, with a large triangular tooth near the lower end; two short, stout spines just above upper end of palm; merus of first and second peræopods much dilated and produced downward in front; peduncle of first uropods with a large spine on lower apex which is nearly half the length of the rami; third uropods with peduncle twice the length of rami; telson broader than long, rounded or subacute behind, with a minute spine and one or more setæ on either side.



*Jassa marmorata.* Three different forms of the second gnathopods of the male are shown. Narragansett Bay.

This species is conspicuously mottled. The ground color is reddish, which is interrupted with large light-colored spots. There is a light spot or band on the head behind the eye; first thoracic segment mostly colored, but the second light, except in the mid-dorsal line and occasionally on the sides; third and fourth segments mostly colored, and the fifth with a broad median blotch; a median dorsal band extending through the following segments, with a lighter band on either side; both antennæ crossed by rather wide bars of color.

Length of a large male, 10 mm.

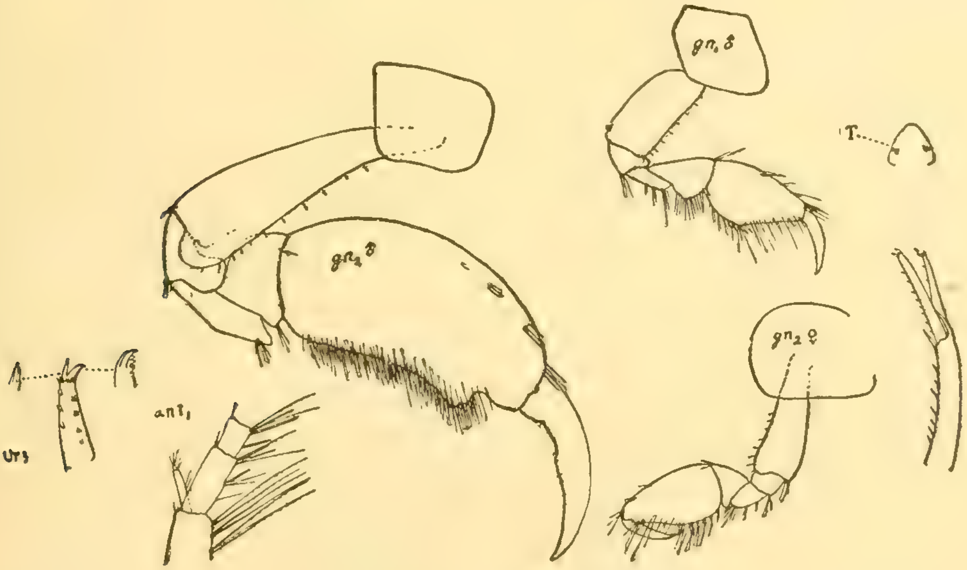
I have compared this species with specimens of *Jassa pulchella*, from North Devon, England, which were received through the kindness of the Rev. T. R. R. Stebbing. There is a striking similarity in the general appearance and color-marking of the two species. Both pairs of antennæ are, however, much stouter in *marmorata;* the flagellum of the first pair is not so elongate and is composed of fewer and very much stouter joints and has the first joint much longer. The second antennæ differ considerably in their flagella, which are composed of six joints in the specimens of *pulchella* that were examined, while in our species they are composed of but two. The large hands of the males are much alike in the two species, but are somewhat narrower and with a more slender dactyl and basal process in *pulchella*.

There is an apparent dimorphism among the males of this species, similar to that which is said to occur in European species of the same genus. The different forms of the males of *Jassa pulchella* have been regarded by Boeck and Hoek as due to age. Nebeski, however, does not share this view, since he finds that the two forms of the male are often of equal size. An examination of quite a large number of males of *marmorata* of different ages shows that the changes in form of the large chelipeds are correlated with different stages of growth. In the small males the hands resemble those of the females. In the largest males the hand is elongated, as shown in the figure, and furnished with a long basal projection. Among males of intermediate size this projection is of variable length, but never so large as in the largest specimens. The fact that the two types of hand are found in individuals of about equal size may be accounted for on the supposition that the one form is younger than the other and has not passed through the requisite number of molts to attain the final form, but has grown more rapidly. The rate of growth depends largely on food supply, which may vary considerably in different situations. One individual might easily attain the size of another without having passed through so many periods of molting.

### **Ischyrocerus anguipes** Kröyer.

*Cerapus fucicola* Stimpson, Marine Invert. Grand Manan, p. 48, fig. 34, 1853.
*Podocerus fucicola* Smith, Rept. U. S. Fish Com. 1871–72, p. 565.

Male: Eyes nearly round; first antennæ considerably shorter than second; second joint of peduncle a little longer than third and nearly twice as long as first; flagellum shorter than last two joints of peduncle; secondary flagellum very small, consisting of an elongate joint and a minute terminal joint; second antennæ stout and elongate, last two joints of peduncle of subequal length; flagellum shorter than last joint of peduncle, and composed of five or six joints, of which the first is longest; terminal joints with curved spines; first four coxal plates subquadrate, about as deep as long and as high as their respective segments; first gnathopods small, basal joint broad; carpus rounded and setose behind; hand subovate, palm very oblique and nearly straight, a row of four or five spines beginning near end of palm and extending along posterior margin of hand, finger with inner margin acutely serrate; second gnathopods large, much elongated, basal joint narrow, elongate, gradually widening distally and curved forward, lower anterior angle produced downward into a rounded lobe; ischium



*Ischyrocerus anguipes.* Marblehead Beach, Mass.

produced anteriorly into a prominent rounded lobe, as in first gnathopods; merus with pointed process at infero-posterior angle; carpus very much larger than in *marmorata*, with an angular posterior projection which bears a tuft of setæ; hand elongate, thickened, curved backward, devoid of a basal process, posterior margin somewhat concave and densely fringed with rather short, plumose setæ; a blunt projection near infero-posterior angle of hand; peduncle of first uropods with a spine at distal end, which is less than half the length of rami; terminal uropods with rami very small, scarcely one-fourth the length of peduncle; telson triangular, with rounded apex. In the female the second antennæ are much smaller than in the male, being only a little longer and but little stouter than the first pair, and the body is broader in the middle; second, third, and fourth coxal plates larger and relatively deeper, being somewhat deeper than long; first gnathopods resembling those of male, but with basal joint narrower; second gnathopods very much smaller than in the male, basal joint relatively broader, and widening more toward distal end; merus broadly rounded and setose below; carpus subtriangular, short, produced behind into a setose lobe; hand narrowly ovate; palm slightly sinuate, the upper extremity with a pair of stout spines, between which the tip of the finger closes; one or more stout spines and five or six tufts of setæ above these on posterior margin of hand.

Length, 10 mm.

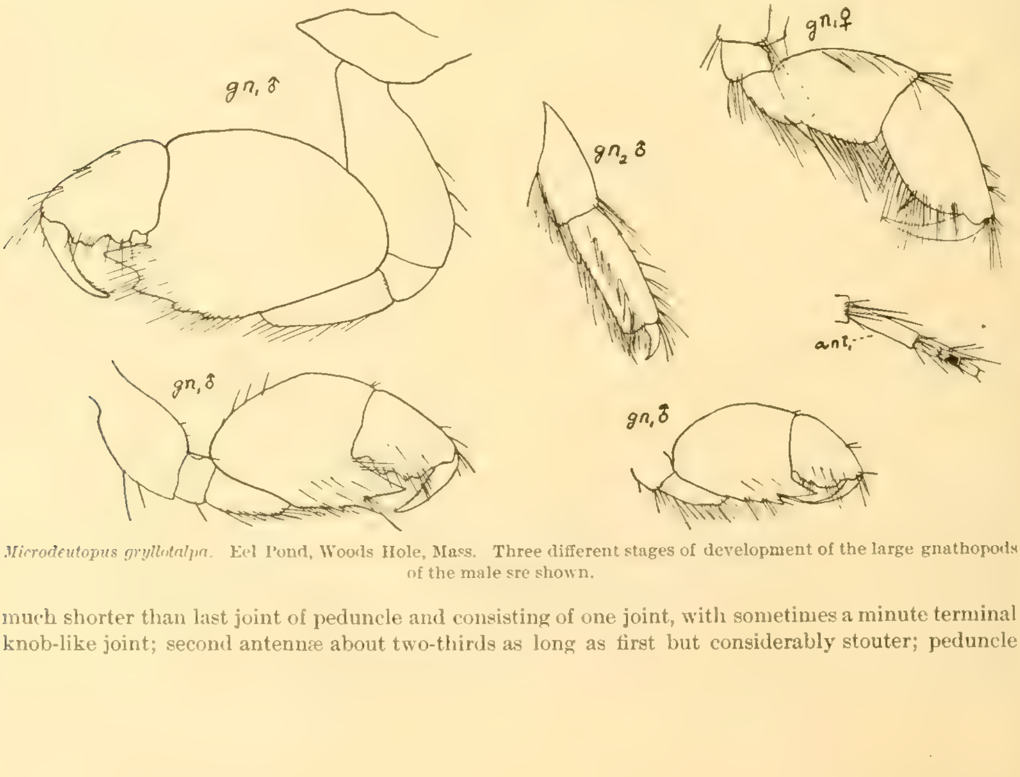
Norway (Sars); Greenland (Kröyer); Labrador; Iceland; Siberian polar sea; Grand Manan (Stimpson); Bay of Fundy (Smith); Marblehead Beach. Professor Smith states that "this species was dredged by Professor Verrill in 4 to 5 fathoms off Watch Hill, R. I., in April, 1873." It seems to be rare on the southern coast of New England.

According to Stimpson, "the color varies from light olive or greenish to light crimson. Eyes usually white. The articles of the antennæ are sometimes alternately red and white." Professor Smith states that some of the specimens taken at Watch Hill "had a transverse dorsal band of red or orange on each segment, and similar ones on the epimera, and were minutely speckled with dark brown; the antennæ and legs were annulated with white and light red or orange.

### **Microdeutopus gryllotalpa** Costa.

*Microdeutopus minax* Smith, Rept. U. S. Fish. Com. 1871–2, p. 565.

Eyes nearly round; first antennæ a little over half the length of body, second joint of peduncle longer than first and over twice as long as third; flagellum longer than peduncle; secondary flagellum much shorter than last joint of peduncle and consisting of one joint, with sometimes a minute terminal knob-like joint; second antennæ about two-thirds as long as first but considerably stouter; peduncle



*Microdeutopus gryllotalpa*. Eel Pond, Woods Hole, Mass. Three different stages of development of the large gnathopods of the male are shown.

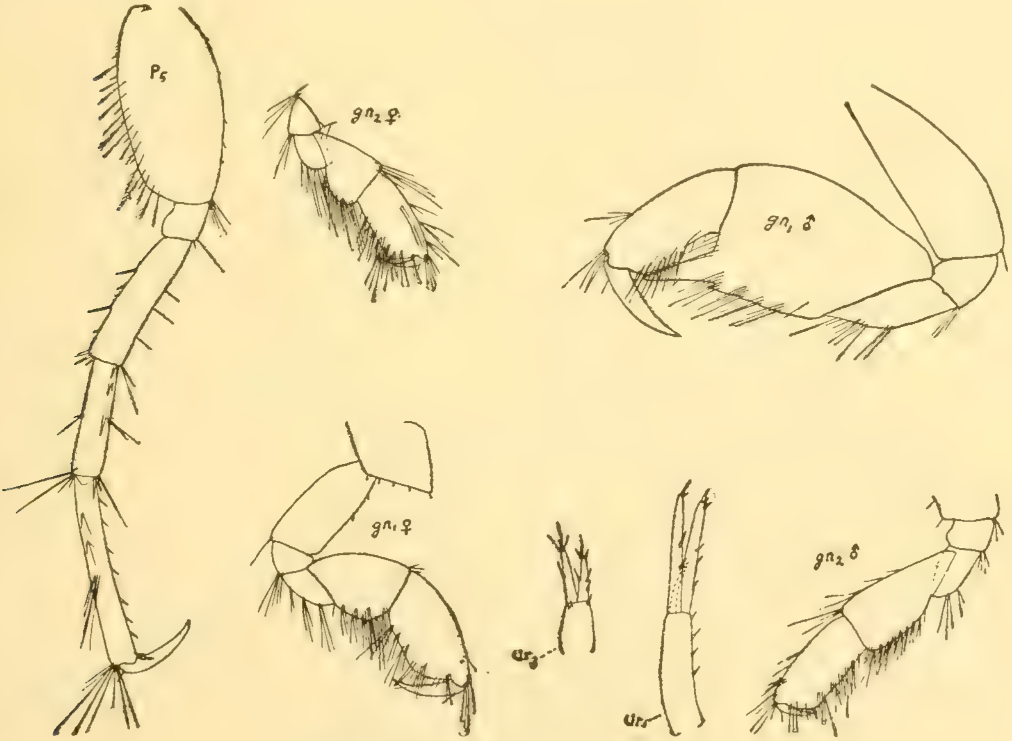
elongated, last two joints of subequal length, terminal one being usually slightly shorter; flagellum rather thick and shorter than last joint of peduncle; coxal plates not as deep as their segments; first gnathopods in male very large and powerful; carpus enormously developed, broadly suboval in outline and produced at postero-distal angle into a lobe which projects beneath the propodus and bears two large teeth; behind the latter two smaller teeth on posterior margin; propodus about two-thirds as broad as long, posterior margin with two or three irregular tuberculiform prominences; first gnathopods in the female simply subchelate; carpus about two-thirds as wide as long; posterior margin rather long and thickly setose; propodus a little narrower than carpus but about as long; palm oblique, evenly convex, with a spine at the posterior end; dactyl serrate within; second gnathopods with carpus narrow with a rather long ciliated posterior margin which is nearly straight; carpus rectangular, over three times as long as wide; palms transverse; dactyl stout, serrated within; terminal peræopods about reaching tip of uropods; first uropods with a long spine at distal end of peduncle which extends nearly to middle of rami; telson oblong, distally rounded.

Length, 8 mm.

European coast from Norway to the Mediterranean; Long Island Sound and Vineyard Sound (Smith); Provincetown (Rathbun); Woods Hole, common in the Eel Pond.

### **Microdeutopus danmonensis** (Bate).

Eyes nearly round; first antennæ over half the length of body, first segment somewhat shorter than head, not so stout as in preceding species; second segment markedly longer than first and over twice the length of third; flagellum slender, longer than peduncle; secondary flagellum about as long as last joint of peduncle and composed of two long segments, and usually a minute terminal knob-like segment; second antennæ about two-thirds as long as first, peduncle elongate, more slender than in *gryllotalpa;* last basal joint not longer than preceding one but equaling or exceeding flagellum; first



*Microdeutopus danmonensis.* Woods Hole, Mass.

gnathopods in male more slender than in *gryllotalpa*, the carpus narrower and produced at postero-distal angle into a narrow triangular process which extends beyond middle of propodus; posterior margin with usually one or more small teeth behind this process; propodus much narrower than in *gryllotalpa*, being fully twice as long as wide, basal half of lower margin smooth; distal part with a low projection; first gnathopods of female similar to those of *gryllotalpa*, but with a shorter carpus and slightly narrower propodus; second gnathopods differing more in the two sexes than in the preceding species; carpus in male elongated, with a slightly curved posterior margin; hand narrower than carpus and nearly as long, over twice but scarcely three times as long as wide, with the palm somewhat oblique; carpus in the female shorter than in the male and with posterior margin strongly convex; hand much as in the male, but slightly shorter; posterior peræopods extending much beyond the uropods; uropods much as in *gryllotalpa*.

Length, 6 mm.

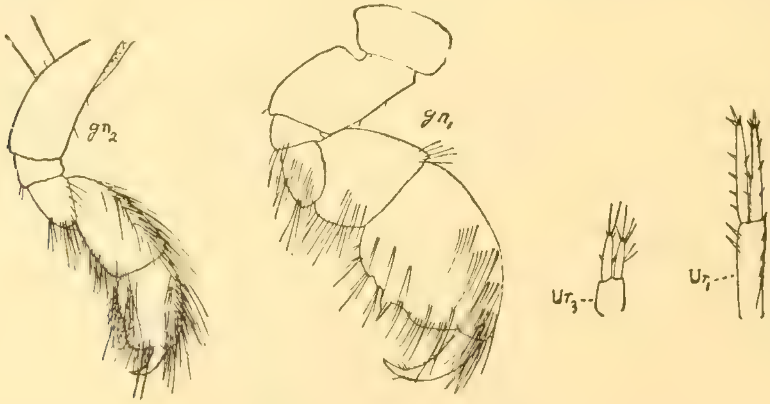
Norway (Sars); British Isles (Bate); Woods Hole, Mass., common in the Eel Pond along with the preceding species.

This species is readily distinguished from the preceding one by the two-jointed secondary flagellum of the first antennæ, by the more slender first gnathopods of the male and their entirely different carpal process, the less elongated hand of the second gnathopods, and the longer and more slender terminal peræopods.

### **Autonoë smithi** Holmes, new species.

*Autonoë* sp. Smith, Rept. U. S. Fish Com. 1871–2, p. 562.

Eyes round; first antennæ nearly as long as body; first joint of peduncle about as long as head and about two-thirds as long as second, which is nearly three times the length of third; flagellum slender, longer than peduncle; secondary flagellum scarcely as long as third joint of peduncle and consisting of two elongate joints and a minute terminal knob-like joint; second antennæ about two-thirds as long as first, subpediform; peduncle elongate, penultimate basal joint extending forward as the penultimate basal joint of antennules, and about equaling preceding joint in length; flagellum stout, six or seven jointed, shorter than last joint of peduncle, its first joint about as long as all succeeding ones; coxal plates small, margins furnished with a few distant setæ, the first four subquadrate, much broader than deep; first gnathopods large and stout, coxal plate somewhat more irregular in outline than in the following pairs of appendages; stout basal joint not more than twice as long as wide, abruptly narrowed near proximal end to about half the width of lower portion; carpus very thick, about as wide as long; hand broadly and irregularly ovate in outline; palm sinuous, convex below and concave above, its thin margin furnished with numerous minute blunt teeth, its upper end defined by a large tooth at the base of which is inserted a stout spine; two prominences on the short posterior margin of hand above this tooth; second gnathopods with carpus oblong, longer than hand; hand oblong, strongly convex in front, slightly narrowed beyond middle; palm transverse, convex; a spine at rounded posterior angle,



*Autonoë smithi*. Woods Hole, Mass.

thin margin of palm finely pectinated; dactyl armed within with about six short, oblique spines; first two peræopods with basal joints narrow and elongated; ischium longer than broad, carpus narrower than merus and slightly tapering toward either end; dactyl slender, a little over half the length of propodus; third peræopods short, fourth much longer, last pair very long and slender; postero-lateral angles of first three abdominal segments rounded and not produced; first uropods narrow, rami subequal to peduncle in length, latter with a long. narrow spine projecting from distal end below rami; rami of second uropods a little longer than peduncle, the latter furnished as in first pair with a long spine at distal end, which extends to about half the length of rami; rami of third uropods subequal and nearly twice the length of peduncle, which is devoid of a terminal spine; telson wider than long, distally rounded.

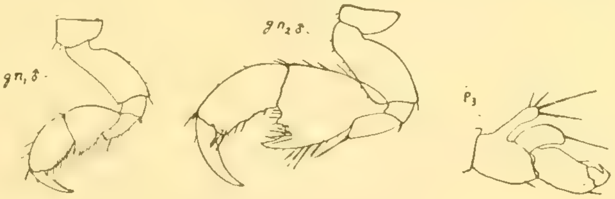
Body and coxal plates with blackish pigment, the fifth thoracic segment lighter than the others; abdomen lighter than thorax; legs transparent and almost devoid of pigment; body and appendages with a diffuse reddish-brown coloration, which is deeper on the large hand, becoming more intense toward the tip and on the base of the dactyl; dorsal side of body crossed with purple, orange, or rose-colored bars; both pairs of antennæ very beautifully and conspicuously marked with spots of red, pink, or orange, these spots on the peduncles of both antennæ at the bases of the setæ, on the flagellum of first antennæ; they are regularly arranged, a pair of oblong spots being separated by a colorless longitudinal interval on each joint. Eyes black.

Length, 6 mm.

Vineyard Sound (Smith) "in tubes in masses of a compound ascidian (*Amouroucium pellucidum* Verrill) in 3 to 8 fathoms."

### **Cerapus tabularis** Say.

Head with a small rostrum and a faint dorsal carina; first and second antennæ subequal in length, and in the male a little over half the length of body; first segment of first antennæ stout, laterally compressed, furnished below with a carina which is more prominent near the base; second and third segments subequal; flagellum three-jointed and about as long as last joint of peduncle; second antennæ with flagellum three-jointed and nearly as long as last peduncular segment; coxal plates broader than deep; first gnathopods with carpus produced downward at postero-distal angle into a small lobe; propodus oblong, narrower than carpus, but about as long; palm oblique, spinulous; second gnathopods in male with carpus furnished at its postero-inferior angle with a large, acute tooth, above which is a rounded sinus separating the latter from a small rounded tooth; propodus oblong, slightly incurved, nearly as long as carpus, inner margin irregular; dactyl large and stout; second gnathopods in female similar to first pair; third peræopods very small; merus with a long spatulate lobe on posterior margin; carpus articulated to posterior margin of merus above distal end of latter, and produced greatly beyond articulation of oblong propodus; dactyl short and broad with an abruptly recurved hook-like tip; second uropods small, about as large as outer ramus of first pair, ramus very short and furnished with a terminal hook; terminal uropods much like preceding pair but stouter; telson twice as broad as long, distally emarginate, the two lobes rounded and armed above with minute hooks.



*Cerapus tabularis.* After Smith.

Length, 4.4 mm.

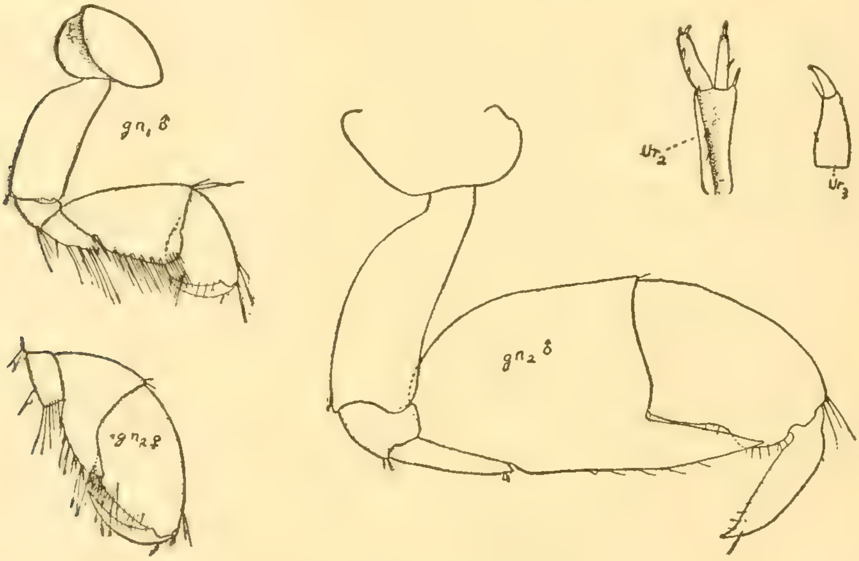
Great Egg Harbor, New Jersey (Say); Vineyard Sound, in masses of the compound tunicate *Amouroucium pellucidum*, and in Noank Harbor, Connecticut (Smith).

This species has the peculiar habit of carrying the tubes in which it dwells, unlike most of the tube-dwelling amphipods which live in a fixed abode. A full description of the structure of this interesting species and several observations on its habits is given by Professor Smith. (Trans. Conn. Ac. Arts and Sci., vol. 4, pp. 269–277, pl. 2, figs. 1–6.)

### **Ericthonius rubricornis** (Stimpson).

*Cerapus rubricornis* Stimpson, Marine Invert. Grand Mann, p. 47, fig. 33, 1853. Bate, Cat. Amphip. Brit. Mus., p. 265, pl. XLV, fig. 4, 1862. Smith, Rept. U. S. Fish Com., 1871–2, p. 565, pl. IV, fig. 18.
*Erichthonius difformis* Smith (not Milne-Edwards), Trans. Conn. Acad. Sci., Vol. IV, 1880, p. 278.

Eyes nearly round; the lateral lobes of head projecting strongly forward; first antennæ but little longer than second, first joint shorter than head, a little over half the length of second which is subequal to third; flagellum short; second antennæ with last basal joint a little longer than preceding one; flagellum short, and furnished like peduncle with long setæ on lower margin; first gnathopods with merus produced below into a triangular process; carpus large, widening distally; hand smaller than carpus, narrowed at base, about two-thirds as broad as long, palm a little convex and cut into minute, narrow, acute teeth; finger armed within with a few short spines with a few smaller spines or acute denticulations between them; second gnathopods in male very large; carpus produced below propodus into a large acute process; propodus oblong, with a prominence near the distal end of lower margin; in the female the carpus produced into a lobe which extends below propodus about as far as tip of closed dactyl; hand ovate, palm very oblique, convex, armed above with a few pairs of spines between which the dactyl closes; first and second peræopods short, basal joints large subovate, though more convex in front; merus expanded and produced downward in front; dactyl long and slender; last pair of peræopods considerably longer than preceding; second and third uropods with margins acute and cut into minute narrow, acute serrations; third uropods with ramus subconical, curved, shorter than peduncle and having two or three short spines at the tip; telson emarginate, lobes armed with numerous, very short, hook-like spines.



*Ericthonius rubricornis.* Newport, R. I.

"Color on the back dark, mottled gray; epimera blackish; terminal articles of the four antennæ bright red; hands yellowish." (Stimpson.)

Length, 9 mm.

Labrador; Grand Manan; Bay of Fundy; whole coast of New England; common near Woods Hole.

This species lives in flexible tubes composed of sand or mud stuck together with a small amount of adhesive, web-like material. According to Stimpson the tubes occur attached to rocks or other objects, generally in large groups. This species is found in shallow water, but Professor Smith states that it may extend to a depth of 100 fathoms or more. It is more common north than south of Cape Cod. South of Cape Cod it has been reported from Vineyard Sound by Smith. I have taken it at

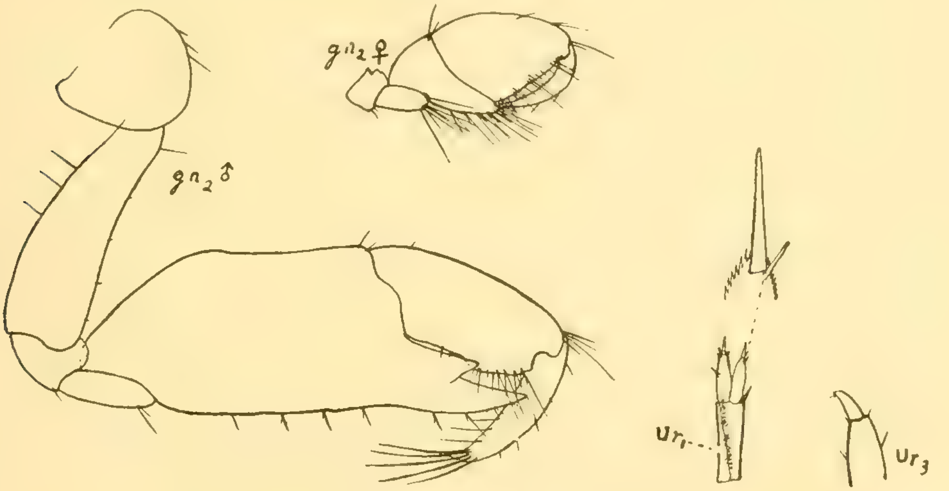
Woods Hole and have received specimens from Newport; and a large number of individuals in their tubes were dredged in Narragansett Bay by the *Fish Hawk* in November, 1899. The latter were all of small size.

This species differs from *difformis* Milne-Edwards, with which it has been united, in that the carpus of the second gnathopods of the male is much broader and stouter, the carpal process being shorter, broader, and devoid of a tooth on the upper margin, and that the propodus is much stouter and has no prominent tubercle near the base of the lower margin; the basal joints of the first and second peræopods are much broader than in *difformis*. *Rubricornis* more closely resembles *E. hunteri*, but the propodus of the second gnathopods in the male in that species has the lower margin straight, more or less laminate, and interrupted by a sharp incision in the middle—a feature not shown in the present species.

### **Erichthonius minax** (Smith).

*Cerapus minax* Smith, Rept. U. S. Fish Com. 1871–2, p. 565.

Eyes large, nearly round; antennæ of subequal length; last two joints of peduncle of first pair subequal; flagellum about as long as peduncle, much longer than in the preceding species; second antennæ more slender than in *rubricornis* and not furnished below with so many nor such long setæ; flagellum nearly as long as peduncle; first gnathopods short, carpus large, distally widening, setose behind; hand much as in *rubricornis*, the dactyl acutely serrulate within; second gnathopods in male very large, merus very small; carpus elongated, produced below propodus into a very large acute process, which has a very large tooth on its upper edge; propodus narrower than in *rubricornis*, with a low elevation near distal end of lower margin; dactyl with long setæ at tip; second gnathopod of female very much like those of preceding species; first uropods projecting beyond second and third, peduncle slender and much longer than rami; inner margin of peduncle of second uropods with acute serrations; margins of rami of second and third uropods acutely serrate, the serrations being larger on inner rami, terminal uropods and telson much as in the preceding species.



*Erichthonius minax*. Gnathopods of male and female drawn to same scale.

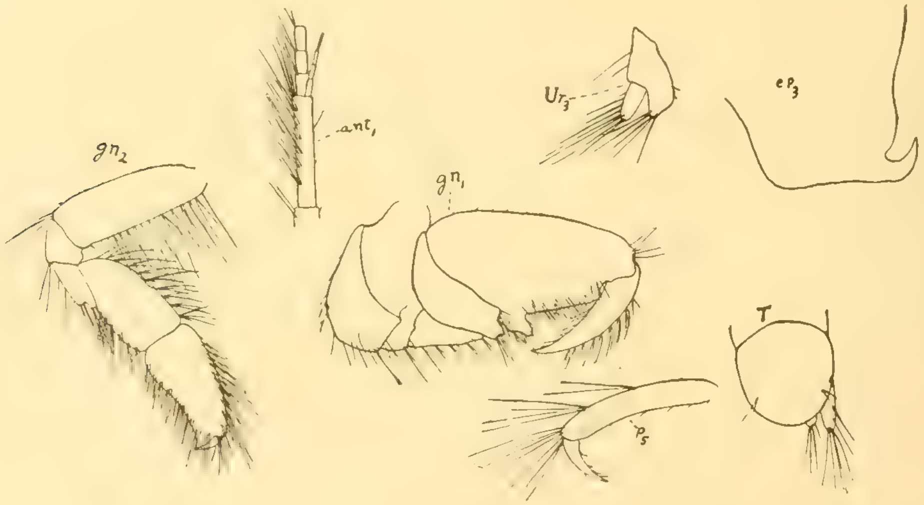
This species is more closely allied to *E. difformis* than the preceding one; it differs from that species in having no tooth on the inner margin of the propodus of the large hand of the male, in having a large tooth near the middle of the upper side of the large carpal process instead of a small or obsolescent one near the tip, in having much broader basal joints on the first and second peræopods, and in having longer and more slender terminal peræopods.

Length, 6 mm.

Long Island Sound; Vineyard Sound (Smith); common at Woods Hole in the Eel Pond; off Gay Head; Great Egg Harbor, New Jersey.

### **Unciola irrorata** Say.

Body depressed; eyes nearly round; head produced into an acute rostrum; antennæ of subequal length and over half the length of body; peduncles elongate, that of first pair not so long as peduncle of second and much more slender, with second joint nearly twice the length of first and third; flagellum of first antennæ much shorter than peduncle; secondary flagellum consisting of four joints and shorter than last basal joint; peduncle of second antennæ very stout in the adult male and laterally compressed at the base, antepenultimate joint with a rounded anterior lobe, penultimate joint high at base, but tapering distally, armed within with a row of spines and in some specimens having an inferior lobe at proximal end; last joint subcylindrical or only slightly tapering, nearly as long as but much narrower than the preceding one; flagellum often not longer than last basal joint; in the female the second antennæ much more slender than in the male, and but little compressed laterally at base; penultimate joint scarcely tapering; last basal joint and flagellum much as in the male; anterior gnathopods very stout, of similar form in both sexes; basal joint very thick and hollowed out anteriorly to receive the carpus and hand; carpus short, appearing as if forming a part of the hand; hand with carpus irregularly ovate, a process at upper end of palm carrying a stout spine; second gnathopods small, hand oblong, widest at the base where it is as broad as the carpus, narrowing distally; palm short, nearly transverse, intero-posterior angle of hand produced, posterior margin above this angle concave; both margins of carpus and hand and anterior margin of basal joint furnished with tufts of long setæ; last pair of peræopods much longer than others; dactyl long and slender; all of the coxal plates much broader than high and the posterior ones produced at posterior angle, as are also the segments above them; sides of first and second abdominal segments produced below into an acute posterior tooth; postero-lateral angle of third segment produced into a large, strongly upturned hook; uropods short; peduncle of first pair with a short spine or tooth projecting backward from posterior end beneath the rami; inner posterior angle with a strong spine; rami about two-thirds the length of peduncle; peduncle of second pair with a strong spine at inner posterior angle, but no terminal spine or tooth beneath rami; terminal uropods small; ramus short, not half the length of peduncle; inner posterior angle of peduncle produced into a lobe which extends posteriorly as far as tip of ramus, giving the appendage the appearance of being two-branched; telson rather large and rounded behind.



*Unciola irrorata*, male. Off Fishers Island. $ep_3$, Third abdominal segment.

Color in life usually bright red. The red is generally mottled with white and occasionally individuals are met with which have very little red color. The first segment of the thorax is more colored than the others. Bases of both antennæ red with orange; flagella with a double row of red spots, one pair to each segment.

Length, 15 mm.

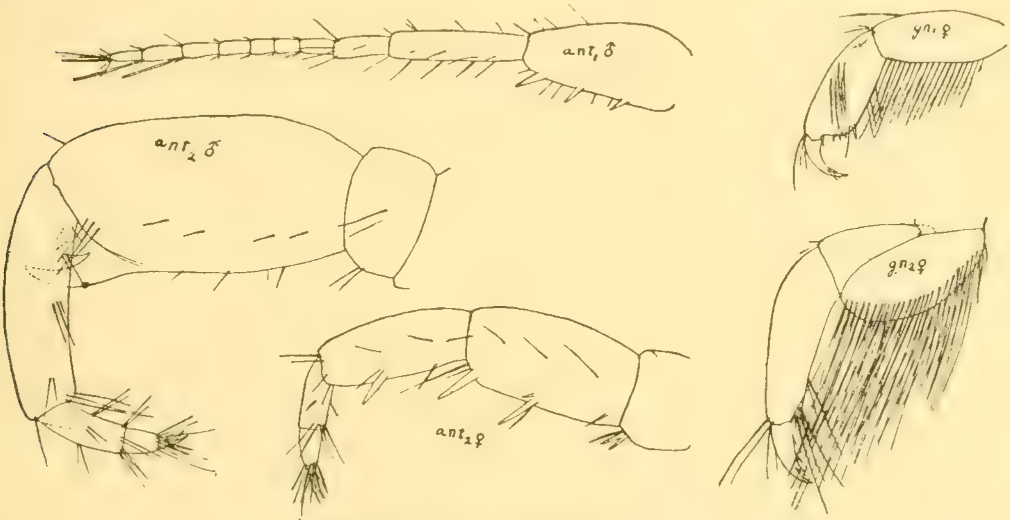
Great Egg Harbor, New Jersey (Say); Connecticut to Bay of Fundy (Smith); Nova Scotia; Labrador; Greenland; Spitzbergen; Norway.

Ranges in depth from low tide mark to over 500 fathoms. Found in great abundance almost everywhere along the New England coast.

This species in life is beautifully colored. The body is mottled with bright crimson; head with a broad median band of crimson which is bifurcated in front; first segment of thorax more colored than the others; a row of small crimson spots on either side of the mid-dorsal line; bases of both pairs of antennæ crowned with orange; flagella with double rows of crimson spots, a pair to each segment; large hand with crimson blotches.

### **Corophium cylindricum** (Say).

Antennæ of nearly equal length in the female and about half as long as body; peduncle of first pair with first joint rather stout, a little longer than second, and armed below with three or four spines; third joint scarcely half as long as second; flagellum somewhat shorter than peduncle; second antennæ stout; very large in the male, the thick fourth joint produced into a large upturned spine at distal end of lower margin, above which are two teeth; fifth joint subcylindrical, scarcely half as thick as preceding one, distal end produced into a lobe on one side; flagellum shorter than preceding joint of peduncle, three-jointed, first joint longer than second, third joint minute, bearing two curved terminal spines and numerous setæ; the second antennæ in the female with peduncle quite different from that of the male, although the flagellum is much the same in both sexes; fourth joint less stout relatively than in the male, devoid of large curved spine at distal end, and armed with two or three large spines on lower side; in last joint lobe at distal end slight or absent and lower margin armed with one or more strong spines; first gnathopods with carpus and hand of subequal size, the former fringed behind with long plumose setæ; hand oblong; palm nearly transverse, rounded behind, where it bears a prominent spine; several smaller spines near margin of palm; finger with a small subterminal spine; second gnathopods with merus articulated below carpus as far as distal end of the latter and fringed with two rows of very long, plumose setæ; propodus long, somewhat tapering, not chelate, infero-posterior angle produced into a tooth; finger with one or two spines on lower margin behind tip; first and second peræopods subequal, merus expanded to twice the width of succeeding joints; dactyl slender, gently curved, about as long as propodus; fifth peræopods slender, nearly twice the length of preceding ones, both margins of subovate basal joint with long, plumose setæ; propodus nearly four times as long as the curved dactyl and furnished with a tuft of very long setæ at tip; first



*Corophium cylindricum.* Woods Hole, Mass.

uropods extending beyond the others; rami about half the length of peduncle; ramus of terminal uropods flattened, broadly ovate, the margins furnished with long setæ.

Specimens taken in the Eel Pond at Woods Hole had the body marked with purplish-brown pigment cells; a dark, transverse band across the posterior end of each segment and another near the middle; anterior portion of head dark. Peduncles of both antennæ with a few pigment cells near the base; rest of body pellucid with sometimes a tinge of reddish-brown on the antennæ; eyes black.

Length, 3–4 mm.

New Jersey (Say); New Jersey to Vineyard Sound (Smith); Provincetown (Rathbun).

This species lives in soft tubes, although it is often found free. It is common among hydroids, seaweed, on piles, and on eel-grass. Its tubes may be found in abundance on the eel-grass, especially near the roots. A very common species.

### **Siphonœcetes cuspidatus** Smith.

"Male: Head produced into a long, slender, acute rostrum, and each side between the antennula and antenna into a long lobe, rounded at the end where the eye is situated, and contracted toward the base. Antennula reaching about to the middle of the fourth segment of the peduncle of the antenna; segments of the peduncle equal in length; flagellum scarcely longer than a segment of the peduncle, and composed usually of five segments. Antenna a little longer than the body; third segment of the peduncle a little longer than any segment of the peduncle of the antennula; fourth segment nearly twice as long as the third; last segment nearly one-half longer than the third; flagellum a little shorter than the last segment of the peduncle. Legs much like Kröyer's figures of *S. typicus*, those of first pair with the carpus twice as long as broad; propodus slightly narrower and a little longer than the carpus, the posterior edge furnished with long hairs and several stout spines. Legs of the second pair much stouter. Posterior caudal stylets with the terminal process fully as long as the ramus itself; the ramus as broad as long, the extremity obtusely rounded and furnished with very long hairs; telson broader than long, transversely elliptical. In the female the antennæ and second pair of legs are more slender than in the male.

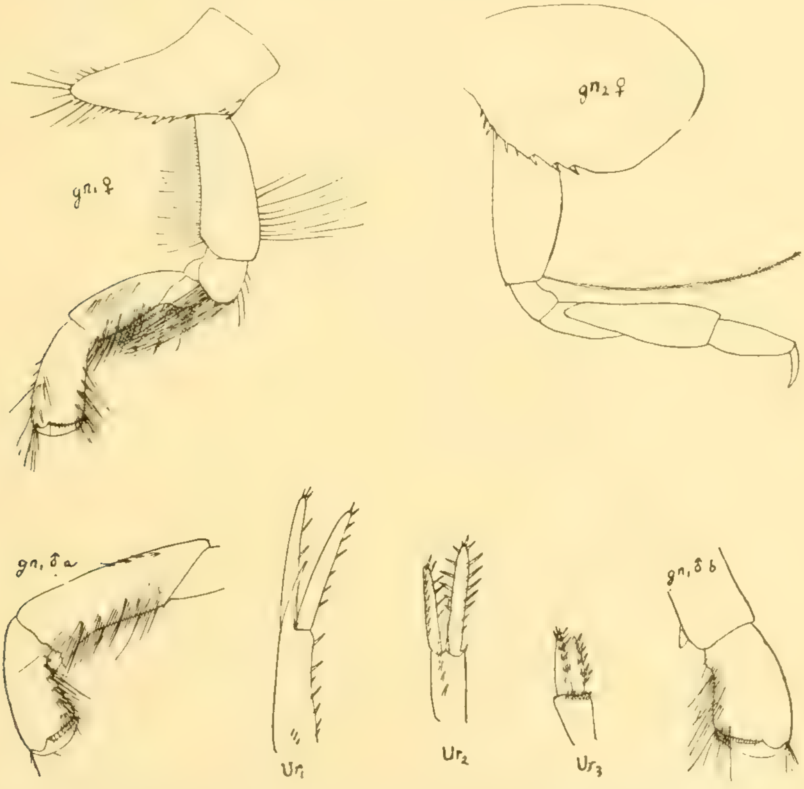
In alcoholic specimens the antennulæ are marked with narrow bands of black or dark brown upon each segment of the flagellum and at both ends of the second and third segments of the peduncle, and the antennæ are obscurely branded or tinged with a lighter color.

Length, about 6 mm. In inhabits tubes constructed of grains of sand. In deep water off Vineyard Sound and Buzzards Bay."

I have not met with this species, and have therefore simply quoted Professor Smith's description.

### **Ptilocheirus pinguis** Stimpson.

Body thick; eyes oval or nearly reniform; first antennæ about half the length of body; first basal joint nearly as long as second, which is nearly three times the length of third; flagellum slender, longer than peduncle; secondary flagellum composed of about seven joints; second antennæ about two-thirds as long as first pair, subpediform; flagellum a little longer than last joint of peduncle, but not nearly so long as last two; coxal plates of first four peræopods well developed, deeper than their segments, their lower margins strongly setose and their postero-lateral angles with a few spine-bearing serrations; first gnathopods with coxal plates much smaller than in the following three pairs and very much produced forward so as to reach anterior end of head; anterior margin and a portion of posterior margin of basal joint furnished with long setæ; lower margin of ischium and posterior margins of merus, carpus, and, to a less extent, the propodus furnished with setæ, those on ischium being especially long; carpus elongate; hand subquadrate, widening distally, palm nearly straight and slightly oblique, with a spine at its posterior angle; first gnathopods in the male larger and stouter than in the female; basal joint thicker, relatively longer and stouter, and furnished with a stout, spine-like process near distal end of lower margin, which is absent in the female; propodus a little wider than in the female and coxal plate larger; propodus held bent inward so that it stands nearly at right angles to the carpus; second gnathopods longer than first; coxal plate suboval in form, projecting much beyond the others in the adult male but not in the female; basal joint with anterior margin densely fringed with very long, slender setæ; carpus narrow and elongate, much exceeding propodus; propodus narrow, not chelate, tapering toward distal end; both margins of carpus and propodus fringed with tufts of setæ; first and second peræopods equal; merus much longer and wider than carpus, which is wider than the slender, tapering propodus; dactyl slender, nearly straight, about three-fourths the length of propodus; last three pairs with basal joints broad; third pair short, about half the length of fifth; third abdominal segment about as long as two preceding ones combined; posterior margins of fourth and fifth abdominal segments with a row of spines on either side of mid-dorsal line; uropods projecting backward about equally far; peduncles nearly as long as rami, those of first and second pairs with a long spine at distal end beneath the rami; rami very spiny; telson broader than long, posterior margin produced backward and rounded in the middle, a spine-like eminence above each postero-lateral angle, and in front of each eminence an oblique row of four or five closely set spines.



*Ptilocheirus pinguis.* $gn_1$♂*a* shows the propodus of the male oblique to the carpus as it naturally stands; $gn_1$♂*b* shows the propodus drawn after being flattened down. In the second gnathopod of the female the setæ are not drawn, only one being inserted to show the length attained by the setæ on the anterior margin of the basal joint.

The dark pigment of this species is very well preserved in alcoholic specimens. The antennæ and legs are devoid of pigment except on the basal joints of the last three pairs of peræopods. The head is pigmented above. The thoracic segments are crossed by pigmented bars, the large first segment of the male having a round, comparatively clear spot on either side. In each pigmented bar on the thorax is often a narrow transverse light-colored band connecting light spots on either side. Pigment occurs also upon the coxal plates. The eyes in alcoholic specimens are black. There is considerable variation in the amount of pigment as well as in the color pattern.

Length, 13 mm.

Grand Manan (Stimpson); "Common on the whole coast of New England upon muddy bottoms, and north to Labrador. In depth it extends down to 150 fathoms, and probably much farther." (Smith.) This species is one of the most abundant of the New England Amphipoda. I have examined specimens from numerous localities along the New England coast and farther north. It is often associated with *Unciola irrorata* and species of *Ampelisca.*

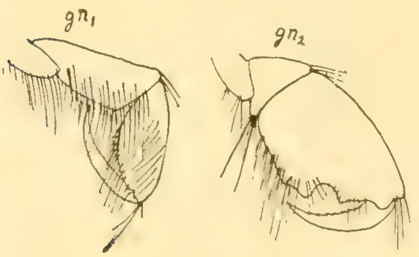
Besides the characters mentioned in the description, the males may be distinguished from the females by the greater width of the anterior end of the thorax, the much longer first thoracic segment, which is about equal to the two succeeding segments, and has a large, round, light-colored spot on each side. The coxal plate of the second gnathopods is especially prominent in large males and has a shallow groove on the outer side. This plate in the female is larger than the others, but does not project much, if any, below them. Stimpson states that the first and second antennæ are about equal in the male and that the first are longer than the second in the female. Most of the males I have examined resembled the females in having the first antennæ longer than the second pair.

In his Catalogue of Amphipodous Crustacea in the British Museum, Bate gives what purports to be a description of a male of this species which was sent him by Doctor Stimpson. The description and the figures drawn from this specimen indicate that it was really a female. I find that the marsupial plates in several females that were examined are very small and of unusual form. Bate had but one specimen of this species, and he probably overlooked the marsupial plates, as one might readily do in a cursory examination, and concluded, therefore, that his specimen was a male.

### **Podoceropsis nitida** (Stimpson).

*Podocerus nitidus* Stimpson, Marine Invert. Grand Manan, p. 45, 1853.
*Podoceropsis excavata* (Bate) Meinert, Naturhist. Tidskr. (3), Vol. XI, p. 152, 1877.
*Xenoclea megachir* Smith, Trans. Conn. Acad. Sci., Vol. III, 1874, p. 32, pl. IV, figs. 1–4.

Eyes rounded-oval, situated at the base of and partly upon the pointed lateral lobes of head; antennæ of nearly equal length, somewhat exceeding half the length of body, and strongly setose; peduncle of first pair subequal to flagellum; second joint of peduncle longer than third, which is slightly longer than first; flagellum consisting of 12–16 joints; second antennæ with last two joints of peduncle of subequal length; flagellum a little shorter than peduncle; anterior five coxal plates somewhat deeper than wide, and deeper than their segments; fifth pair with large anterior lobe as deep as in preceding pairs; first gnathopods with carpus a little longer than hand and about as wide; hand oblong, more or less fusiform, and furnished with a very large dactyl which closes against nearly the whole posterior margin of hand; second gnathopods much stouter than first; ischium with a rather prominent anterior lobe; carpus subtriangular, rather short, with a small, setose posterior process; hand broadly oval, stout, palm oblique, with a deep, rounded excavation near the middle, at either end of which is an angular prominence, the posterior prominence being followed by a smaller, more rounded eminence and furnished on inner side with a strong spine; posterior margin of hand furnished with about five tufts of setæ; postero-lateral angles of third abdominal segment with a very small projection; first uropods with peduncle considerably longer than rami, and furnished with a strong spine projecting beneath the rami at the distal end; third uropods with rami nearly equal to peduncle, the outer slightly the shorter.



*Podoceropsis nitida*, female. Eastport, Me.

Length, 7 mm.

Grand Manan (Stimpson); Eastport, Me.; Norway (Sars); British Isles (Bate); Rhode Island.

This species is described from a single female specimen taken by Hyatt and Van Vleck at Eastport, Me. I have no doubt of its identity with Stimpson's *Podocerus nitidus*, described originally from Grand Manan. In Stimpson's description the second gnathopods are said to have "a short spine on the second article [ischium] in front." What was referred to as a spine was doubtless the small anterior lobe of this joint, as the existence of a true spine in this situation would be a quite unusual occurrence among the Amphipoda. There is no doubt, I believe, that the species subsequently described by Bate from the coast of Northumberland, England, as *Nænia excavata* is the same as this species. The specimen from Eastport agrees well with Bate's description, and also with the description and figures of *excavata* in Sars's "Crustacea of Norway." The posterior gnathopods of the male are described by Sars as "very powerfully developed, with the propodus large and oval in form, not nearly twice as long as it is broad, palm having in the middle a deep sinus defined by two projecting lobes, the posterior of which is acute, the anterior subtruncate at the tip, dactylus very strong and curved."

### NOTES ON EXTRALIMITAL SPECIES OF GAMMARIDEA.

The following species were found in the collections sent me for examination:

*Menigrates obtusifrons* Boeck, Grand Manan.

*Monoculodes borealis* Boeck, five specimens in a bottle labeled *Monoculodes nubilatus* Packard, Labrador. There was also a specimen of *Paradiceros lynceus* in the bottle. The *nubilatus* of Packard is, I believe, synonymous with the latter species, as it has been ranked by Professor Smith. *M. borealis* may prove identical with *M. demissus* Stimpson, but the latter is so poorly described that the identification is very uncertain.

*Ampelisca eschrichti* Kröyer, Caribou Island, 8 fathoms. This specimen was in Packard's collection and named *A. pelagica* Stimpson.

*Haploops tubicola* Lilljeborg, Chat Bay, Labrador, 30 fathoms. In Packard's collection, together with *Byblis gaimardi* Kröyer. The bottle containing these specimens was labeled *Ampelisca gracilis* Packard.

*Haploops robusta* Sars. Grand Manan; Bay of Fundy, and *Albatross* station 2572, together with *H. tubicola.*

*Haploops setosa* Boeck, Albatross station 2055.

*Byblis gaimardi* Kröyer, Eastport, Me., besides the locality mentioned above.

*Melphidippa spinosa* (Goes), Eastport, Me.

*Mæra danæ* (Stimpson) (*Leptothoë danæ* Stimpson), Eastport, Me.

*Dulichia porrecta* Bate, Eastport, Me.

## Tribe CAPRELLIDEA.

Head fused with the first thoracic segment; second gnathopods larger than first; anterior peræopods generally wanting; posterior pairs prehensile; gills usually confined to third and fourth thoracic segments; abdomen rudimentary.

The Caprellidea are divided into two families, the Caprellidæ and the Cyamidæ. The latter family is composed of species parasitic upon the skin of whales. Only the Caprellidæ, therefore, come within the scope of this paper.

| | |
|---|---|
| Mandible with palp | AEGINELLA |
| Mandible devoid of a palp | CAPRELLA |

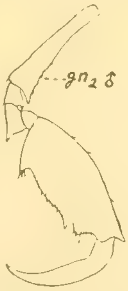
### Æginella longicornis (Kröyer).

*Ægina spinosissima* Stimpson, Marine Invert. Grand Manan, p. 65, 1853.

Body slender, smooth, or armed with numerous spines; head often furnished with a pair of dorsal spines; eyes small; first antennæ long, last joint of peduncle nearly as long as preceding one; flagellum shorter than peduncle; second antennæ extending but little beyond penultimate basal joint of first pair, last joint of peduncle longer than preceding one; flagellum shorter than last joint of peduncle and two-jointed; hand of first gnathopods with palm nearly straight, extending to the proximal end of hand where it is defined by a spine; second gnathopods with basal joint more or less dentate in front and produced below into an acute lobe; ischium and merus with an acute inferior process; hand with a triangular tooth at upper end of palm; a narrow tooth below the middle separated from a triangular eminence below by a narrow sinus; distal end of hand produced into a tooth above the base of dactyl; anterior pair of abdominal appendages two-jointed.

Length, 16 mm.

Siberia; Greenland; Labrador; Grand Manan; Eastport, Me.; Ipswich Bay; Narragansett Bay; Woods Hole.



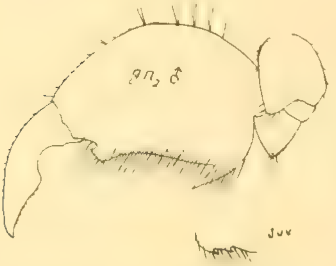
*Æginella longicornis,* var. *spinissisimus.* After Sars.

The development of the spines on the body is very variable. In some specimens they may be reduced to small tubercles, while in others they may be entirely absent. There seem to be all gradations between forms which are very spiny and forms in which the body is smooth

For this reason I have finally decided to follow Mayer in ranking *spinosissima* Stimpson as a variety of *longicornis* Kröyer. I believe that Boeck's *Ægina echinata* is the same as Stimpson's *Æ. spinosissima*, although Sars, Hansen, and Ortmann agree in uniting *Æginella spinifera* (Bell) with Stimpson's species. I have examined several specimens from Labrador and New England, including some from very near the type locality of *spinosissima*, and they agree perfectly with Stimpson's description, and also the description and figures of *Æ. echinata* given by Boeck and by Sars in his Crustacea of Norway. None of the forms I have seen agree with the description and figures of *Ægina spinifera* (Bell) given in Sars's Crustacea of the Norwegian North Atlantic Expedition.

### **Caprella geometrica** Say.

Body unusually robust and devoid of tubercles on spines; head with a large spine pointing anteriorly; antennæ stout, first pair much less than half the length of body, second joint much stouter than third and nearly twice as long; flagellum shorter than peduncle and composed of about twelve segments; second antennæ in adult male about two-thirds as long as first and fringed below with numerous long hairs; hand of first gnathopods with palm straight and armed with a pair of spines at the well-defined upper angle; second gnathopods in adult male, very short and stout, basal joint several times smaller than hand; hand tumid, strongly convex in front; palm strongly setose, with a strong spine at posterior end and a blunt tooth or tubercle near base of finger; gills nearly round; three posterior peræopods stout, carpus as wide as long and about a third the length of propodus; palms of propodi extending nearly to base and defined above by a pair of spines; lower margins of third and fourth thoracic segments produced into laminæ.

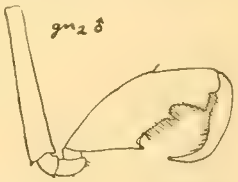


*Caprella geometrica.* juv., Prehensile angle of the 2nd gnathopod of a young male. The larger figure is drawn from a larger male from Woods Hole, Mass.

The color is very variable. Some individuals are nearly colorless; others are uniformly reddish in color, and others again may be variously mottled.

Length of an adult male, 15mm.

This is one of the most common species of amphipod on the southern coast of New England. It is more rare north of Cape Cod, and I have not met with it at all as far north as Maine. Southward it extends to Virginia and perhaps farther. The females do not differ greatly from the males in the form of the body, but they are of much smaller size and have the second antennæ, as in young male, nearly as long as the first; the second gnathopods are relatively smaller and more slender, the basal joint being several times longer than broad; the hand is more like that of the first gnathopods than in the male; the palm has only a small projection armed with a spine at the upper end, and is devoid of a prominent tubercle near the base of the dactyl. As in the other species of the genus, the young males differ in several respects from the adults; the antennæ are more nearly equal in length and the first and second joints of the first pair are less tumid; the gills are more oval in outline; the hand of the second gnathopods is less stout; there are two spinous projections instead of one near the upper end of the palm, and the tubercle near the base of the dactyl is small or absent. This species has been united with *C. acutifrons* Latreille, by Mayer. The two varieties of *acutifrons* which Mayer designates *carolinensis* and *virginia* doubtless belong to the same species that Say described as *geometrica*. The differences between these varieties are small and are for the most part such as occur between individuals of different ages. These varieties, however, present certain differences from the typical form of *acutifrons*, which appear to be constant, and it seems best, therefore, to retain for them the name given by Say.



*Caprella linearis.* After Sars.

### **Caprella linearis** Linnæus.

Body rather slender, smooth above except on some of the posterior segments, which may be furnished with tubercles or even short spines; eyes small, round; first antennæ stout, about half the length of body; joints of the peduncle finely ciliated in adult male; first and third basal joints subequal and shorter than second; flagellum shorter than peduncle; second antennæ sometimes longer than peduncle of first in female, but much shorter in adult male; second gnathopods in female attached in front of middle of segment; hand oval; palm defined above by a spine-bearing projection and bearing a tooth near the lower end; second gnathopods in the male longer than in the female; basal joint relatively narrower and armed, as in the female, with an acute triangular projection at lower end; hand elongated; palm defined above with a spine-bearing projection; a tooth below the middle separated by a rounded sinus from a triangular projection below; posterior peræopods rather stout, propodi narrow, palm about two-thirds as long as posterior margin and defined above by a projection bearing a pair of spines; penes medium, first two thoracic segments in adult males becoming much elongated, equaling in length the succeeding segments of the body.

Length, 16 mm.

European coast to France; Greenland and Labrador (Ortmann); Casco Bay, Me., and Portsmouth, N. H. (Mayer); Grand Manan; off Head Harbor to Salem, Mass.; Annisquam, Mass.; off Montauk Point.

### **Caprella septentrionalis** Kröyer.

Body moderately stout, smooth above except for a few low tubercles on posterior segments; head with a dorsal prominence but no spine; eyes small, round; first antennæ about half the length of body in the male, a little shorter in the female; first joint of peduncle slightly longer than third but much shorter than first; flagellum shorter than peduncle; second antennæ shorter than first; second gnathopods rather short and stout, basal joint much shorter than in *linearis;* hand in the female oval, a spine-bearing process at upper end of palm, a small tooth near distal end of palm, hand in the male longer and narrower than in the female, with teeth similarly placed but with a larger triangular prominence at lower end of palm.

Length, 25 mm.

Arctic regions; northern parts of the European coast; Greenland (Kröyer); Labrador (Smith, Packard); Eastport, Me.

The New England representatives of this species are stout and have the first segments of the thorax shorter than the form figured in Sars's crustacea of Norway, and more nearly approaching some of the several varieties of this species described by Mayer.

### **Caprella stimpsoni** Bate.

Body robust, armed with numerous large, thick spines; head with a large, often bifid, spine or tubercle above; first thoracic segment scarcely longer than deep, somewhat concave above, with a pair of spines in front of and a single spine behind the depression; usually a large spine near middle of second, third, and fourth thoracic segments, and a spine at either end, with smaller spines or tubercles between; second gnathopods with hand and often merus studded with small tubercles.

Norway; Grand Manan (Stimpson); Eastport, Me. Mayer also has examined specimens from the latter locality, which were sent to him by Professor Packard under the name of *Caprella robusta* Stimpson. Some of the specimens I have examined from Eastport were collected by Packard and similarly named by him. All gradations occur between strongly spinous specimens and forms in which the spines are reduced to low tubercles.

The following names may be regarded as synonyms of this variety:

*Caprella robusta* Stimpson (nomen preoc.).

*Caprella punctata* Boeck.

*Caprella septentrionalis* forma $\delta$, *polyceros* Mayer.

## BIBLIOGRAPHY.

BATE, C. SPENCE. Catalogue of the Specimens of Amphipodous Crustacea in the Collection of the British Museum, 1862.

BATE, C. S., and WESTWOOD, J. O. A History of the British Sessile-eyed Crustacea, 2 vols., 1863 and 1868.

BOECK, A. Crustacea Amphipoda Borealia et Arctica. Saerskilt aftrykt af Videnskabs-Selskabet Forhandlingar 1870.

——. De Skandinaviske og Arktiske Amphipoder. Christiania, 1872–1876.

BOSC, D'ANTIC, L. A. G. Histoire Naturelle de Crustacés, 1802.

BOVALLIUS, C. Contributions to a Monograph of the Amphipoda Hyperiidea. Kongliga Svenska Vetenskaps Akademiens Handlingar, Ny Följd, Band 21 and 22, 1887–1891.

DE KAY, J. E. Zoology of New York, Part VI, Crustacea, 1844.

DELLA VALLE, A. Gammarini del Golfo di Napoli. Fauna und Flora des Golfes von Neapel, 20. Monographie, 1893.

GOULD, A. A. Report on the Invertebrata of Massachusetts, 1841.

HANSEN, H. J. Malacostraca Marina Groenlandiæ Occidentalis. Særtryk af Videnskabelige Meddelelser fra den naturhistoriske Forening i Kjøbenhavn, 1887.

HERRICK, C. L. Contribution to the Fauna of the Gulf of Mexico and the South. Memoirs Denison Scientific Association, Vol. I, No. 1, 1887.

HOLMES, S. J. Synopses of North American Invertebrates. XVIII.—The Amphipoda. American Naturalist, Vol. XXXVII, 1903, p. 267.

———. Phototaxis in the Amphipoda. American Journal Physiology, Vol. V, 1901, p. 211.

———. Observations on the Habits and Natural History of Amphithoë longimana Smith. Biological Bulletin, Vol. II, 1901, p. 165.

———. Death Feigning in Terrestrial Amphipods. Biological Bulletin, Vol. IV, 1903, p. 191.

———. Sex Recognition in Amphipods. Biological Bulletin, Vol. V, 1903, p. 288.

JUDD, S. D. Descriptions of Three Species of Sand Fleas (Amphipods) collected at Newport, Rhode Island. Proceedings U. S. National Museum, Vol. XVIII, 1896, p. 593.

KRÖYER, H. N. Grönlands Amfipoder, 1838.

MAYER, P. Die Caprelliden des Golfes von Neapel. Fauna und Flora des Golfes von Neapel, VI. Monographie, 1882; Nachtrag XVII, Monographie, 1890.

MIERS, E. J. Report on the Crustacea collected by the Naturalists of the Arctic Expedition in 1875–76. Annals and Magazine Natural History (4), Vol. XX, 1877, pp. 52–66 and 96–110.

MILNE-EDWARDS, H. Extrait de recherches pour servir à l'histoire naturelle des Crustacés Amphipodes. Annales Sciences Naturelles, T. XX, 1830.

———. Histoire Naturelle des Crustacés, T. III, 1840.

ORTMANN, A. Crustacea and Pycnogonida collected during the Princeton Expedition to North Greenland. Proceedings Academy Natural Sciences, Philadelphia, 1903, p. 144.

PACKARD, A. S. A List of the animals dredged near Caribou Island, Southern Labrador, during July and August, 1860. Canadian Naturalist and Geologist, Vol. VIII, 1863, p. 401.

———. View of the Recent Invertebrate Fauna of Labrador. Memoirs Boston Society Natural History, Vol. I, 1867, p. 262.

RATHBUN, R. The Littoral Marine Fauna of Provincetown, Cape Cod, Massachusetts. Proceedings U. S. National Museum, Vol. III, 1880, p. 116.

SARS, G. O. The Norwegian North-Atlantic Expedition. VI. Zoology, Crustacea I, 1885.

———. An Account of the Crustacea of Norway, Vol. I, Amphipoda, text and plates, 1895.

SAY, THOS. On a new genus of the Crustacea, and the species on which it is established. Journal Academy Natural Sciences, Philadelphia, Vol. I, 1817, part 1, p. 49.

———. An Account of the Crustacea of the United States. Journal Academy Natural Sciences, Philadelphia, Vol. I, 1817–18, part 1, pp. 57, 65, 97, 155; part 2, pp. 235, 313, 374, 423.

SMALLWOOD, M. E. The Beach Flea, Talorchestia longicornis. Cold Spring Harbor Monographs, No. 1, 1903.

SMITH, S. I. Report upon the Invertebrate Animals of Vineyard Sound and the Adjacent Waters. Amphipoda by Prof. Smith. Report U. S. Fish Commission, 1871–72. 1873.

———. Tube-building Amphipoda. Annals and Magazine Natural History (4), Vol. XIV, 1874, p. 240; also in American Journal Science, June, 1874.

———. Occurrence of Chelura terebrans, a Crustacean destructive to the Timber of Submarine Structures, on the Coast of the United States. Proceedings U. S. National Museum, Vol. II, 1879, p. 232.

———. Contributions to the Natural History of Arctic America made in connection with the Howgate Polar Expedition, 1877–78. Crustacea by Prof. Smith. Bulletin U. S. National Museum, No. 15, 1879, p. 139–140.

———. On the Amphipodous Genera Cerapus, Unciola, and Lepidactylis described by Thos. Say. Transactions Connecticut Academy Arts and Sciences, Vol. IV, 1880, p. 268.

———. Recent Dredgings by the United States Fish Commission off the South Coast of New England, with some Notice of the Crustacea obtained. Annals and Magazine Natural History (5), Vol. VII, 1881, p. 143.

———. Preliminary Notice of the Crustacea dredged in 64 to 325 fathoms off the south coast of New England, etc. Proceedings U. S. National Museum, Vol. III, 1881, p. 431.

———. List of the Crustacea dredged on the coast of Labrador by the expedition under the direction of W. A. Stearns in 1882. Proceedings U. S. National Museum, Vol. VI, 1883, p. 218.

———. Review of the Marine Crustacea of Labrador. Proceedings U. S. National Museum, Vol. VI, 1883, p. 223.

SMITH, S. I., and HARGER, O. Report on the Dredgings in the Region of St. Georges Banks in 1872. Transactions Connecticut Academy Arts and Sciences. Vol. III, 1874.

STEBBING, T. R. R. Report on the Amphipoda. Challenger Reports, Vol. XXIX, 1888.

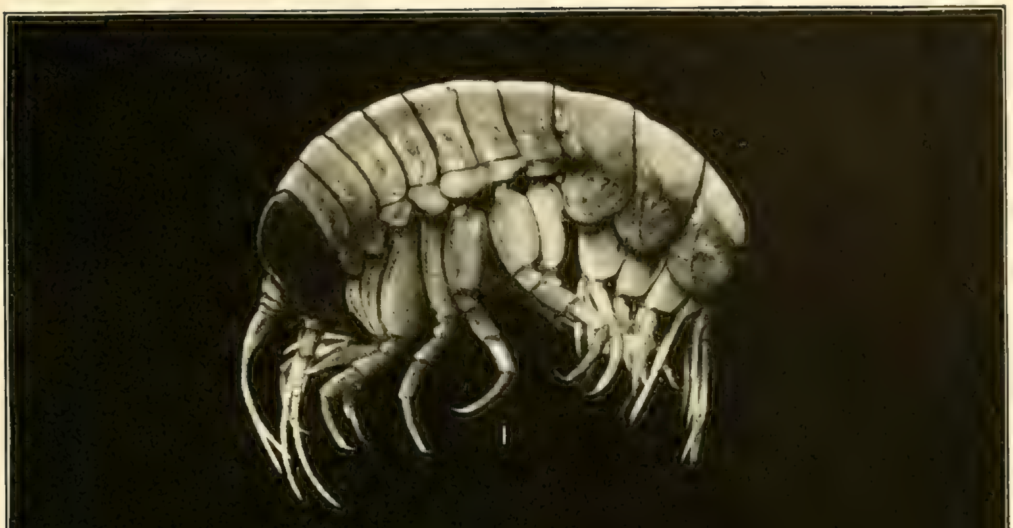
———. Amphipoda from the Copenhagen Museum and Other Sources. Transactions Linnaean Society London (2), Zoology, Vol. VII, 1899, p. 395.

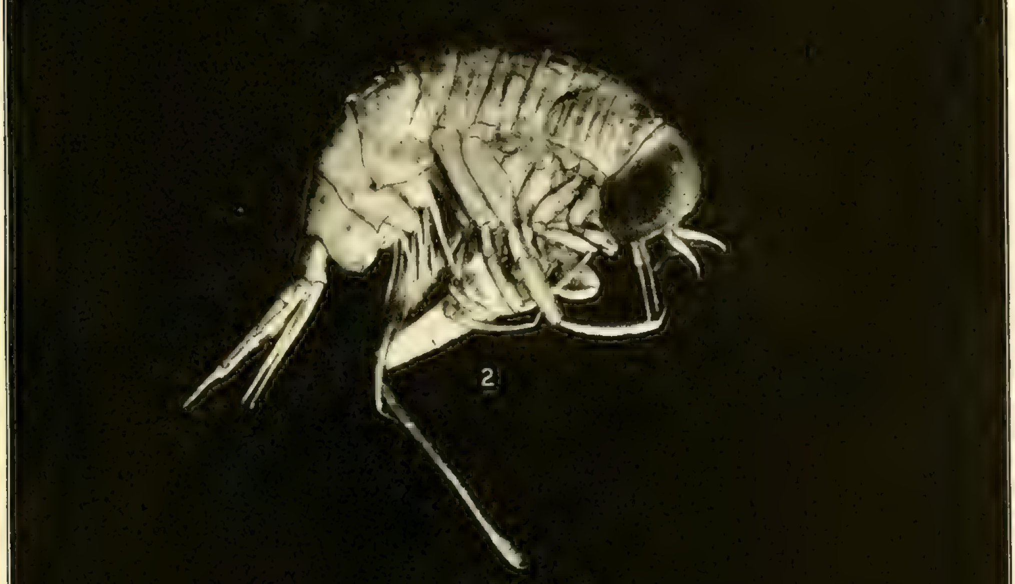
STIMPSON, WM. Synopsis of the Marine Invertebrata of Grand Manan, 1853. Smithsonian Contributions, Vol. VI, 1851.

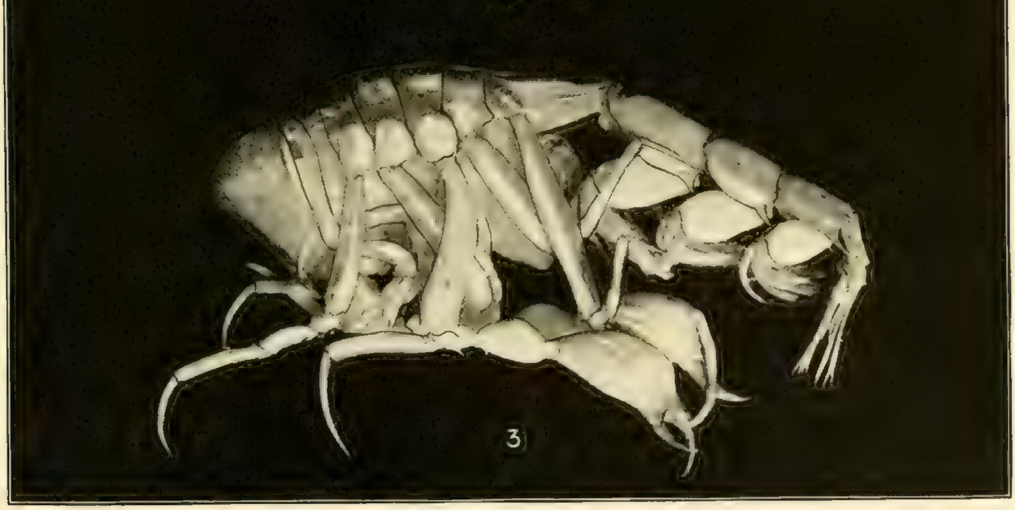
———. Synopsis of the Marine Invertebrata collected by the late Arctic Expedition under Dr. I. J. Hayes. Proceedings Academy Natural Sciences, Philadelphia, 1863.

WHITE, A. List of Specimens of Crustacea in the Collection of the British Museum, 1847.

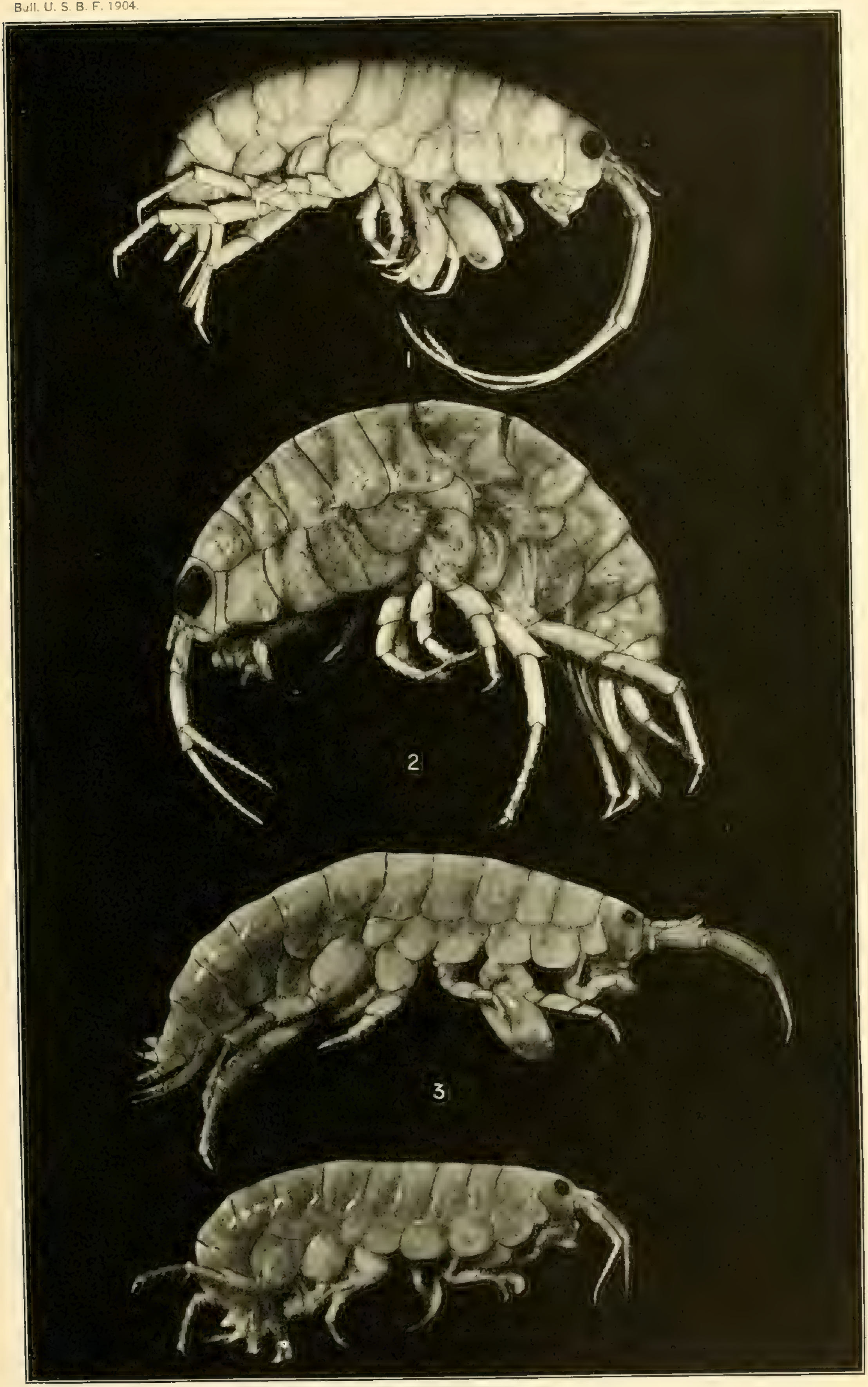
WHITEAVES, J. F. Catalogue of the Marine Invertebrata of Eastern Canada. Geological Survey Canada, 1901, Amphipoda, p. 218.



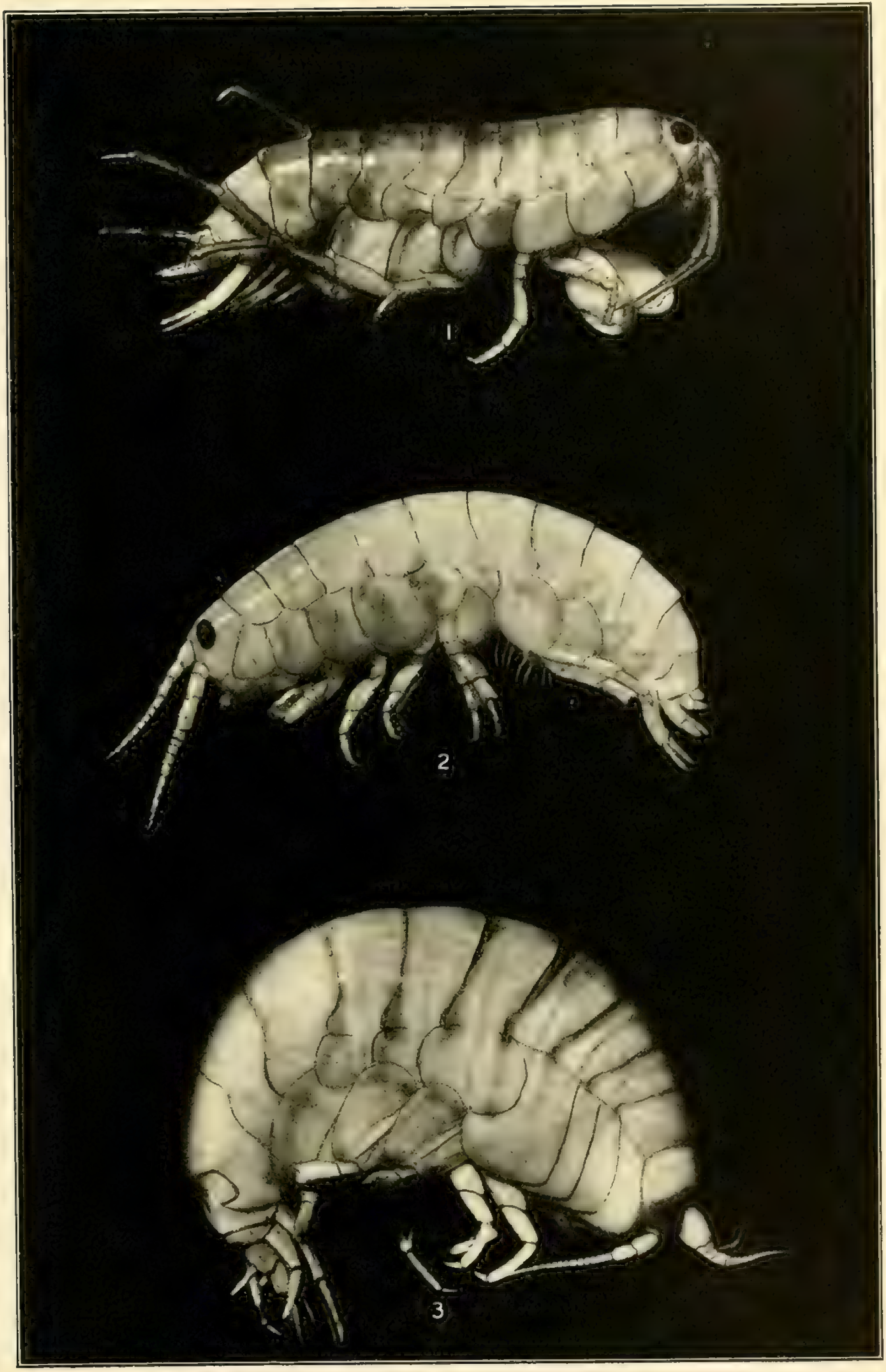




1. *Hyperia galba.* Grand Manan. In many individuals the antennæ are much longer than in the one photographed
2. *Euthemisto bispinosa.* Vineyard Sound. In larger specimens the dorsal spines are much more prominent than in the one photographed
3. *Phronima sedentaria.* Grand Manan.

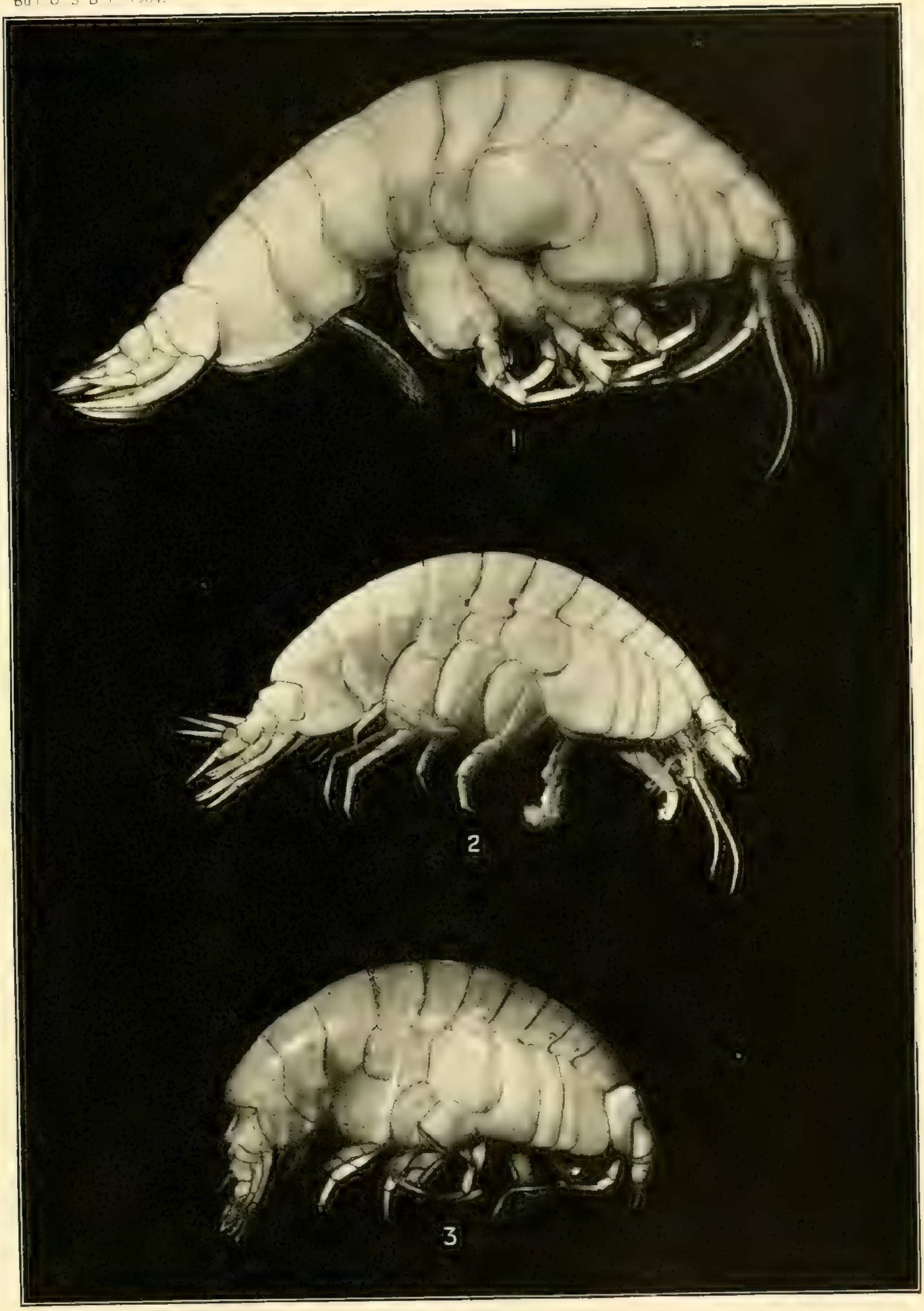


1. *Talorchestia longicornis.* Adult male from Woods Hole, Mass.
2. *Talorchestia megalophthalma.* Female from Woods Hole.
3. *Orchestia agilis.* Upper figure male, lower female. Woods Hole.

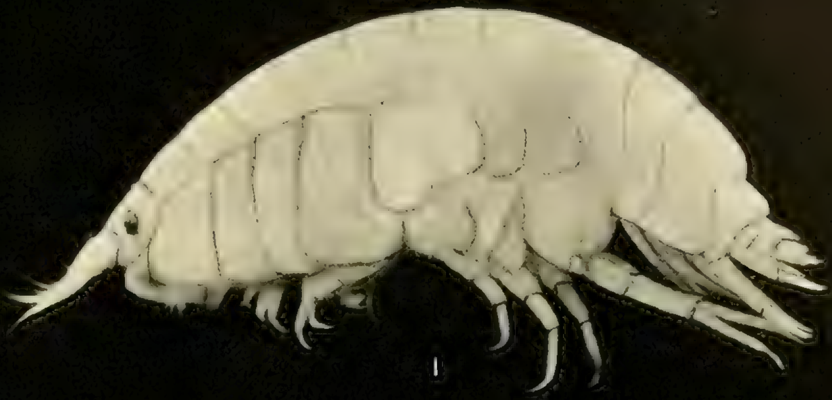


1. *Orchestia palustris*, male. Woods Hole.
2. *Hyale littoralis*. Woods Hole.
3. *Anonyx nugax*. Vineyard Sound.

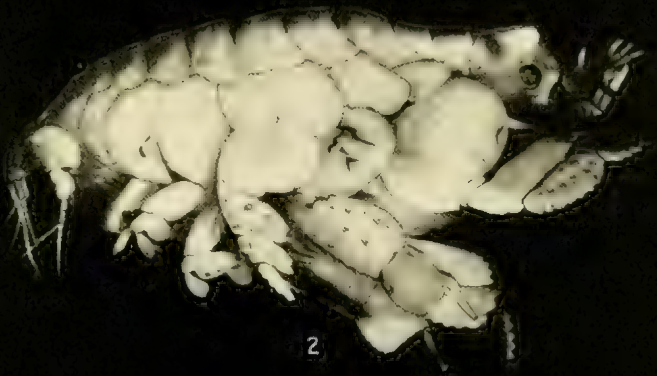
PLATE IV.



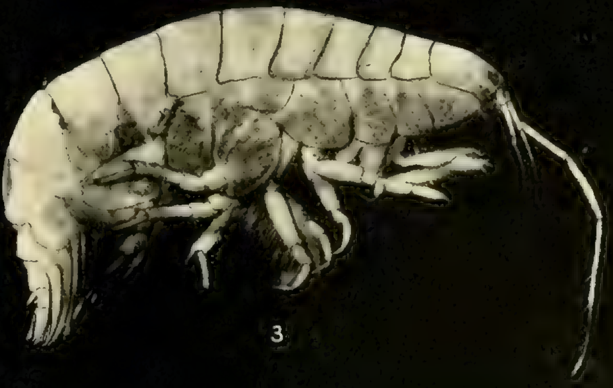
1. *Hoplonyx cicada.* Vineyard Sound.
2. *Hippomedon serratus.* Type specimen, from Newport, R. I.
3. *Tryphosa pinguis.* Vineyard Sound.



1

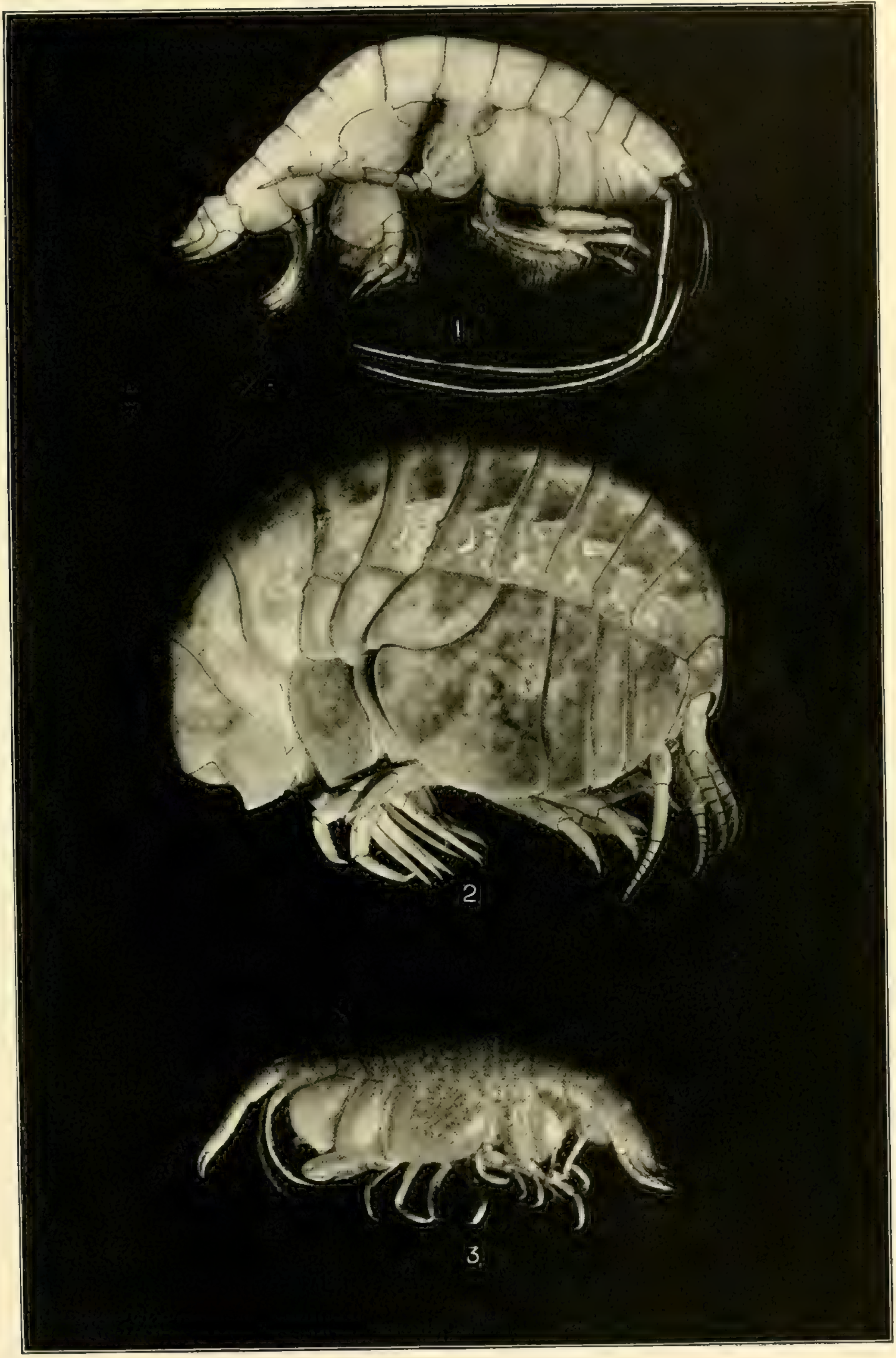


2



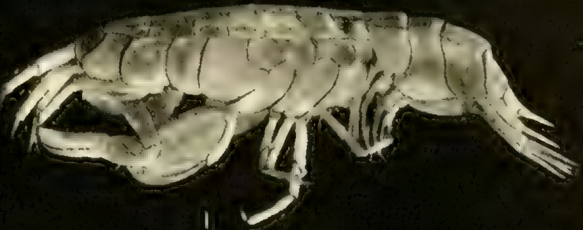
3

1. *Lysianopsis alba.* Woods Hole.
2. *Haustorius arenarius.* Off Marthas Vineyard.
3. *Byblis serrata.* Woods Hole.

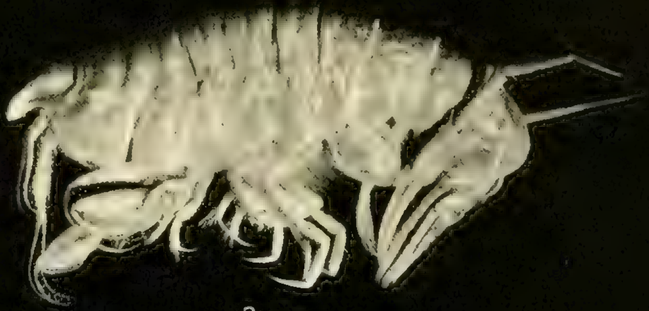


1. *Ampelisca compressa.* Near Woods Hole.
2. *Stegocephalus inflatus.* Off Head Harbor, Maine.
3. *Metopa grœnlandica.* Albatross Station 2057.

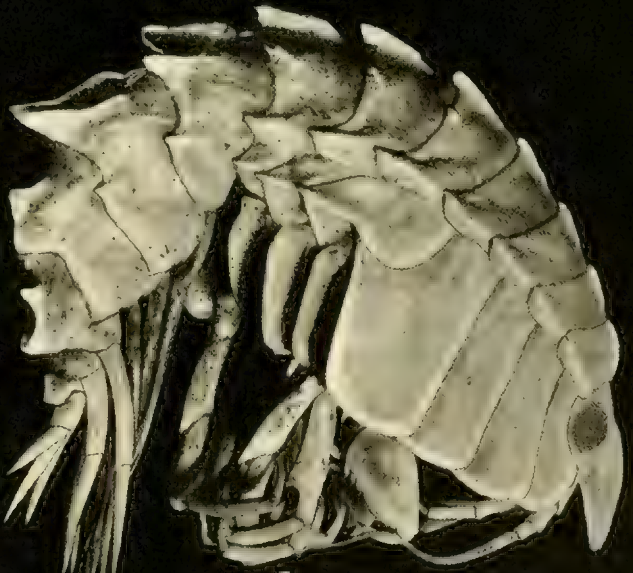
PLATE VII.



1



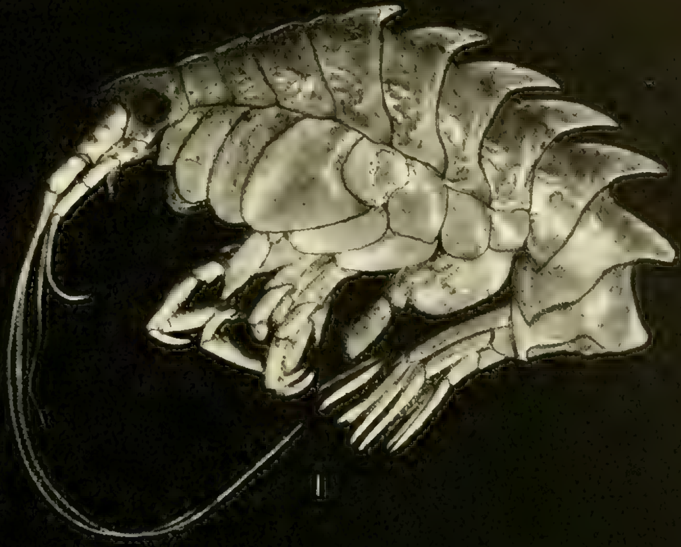
2



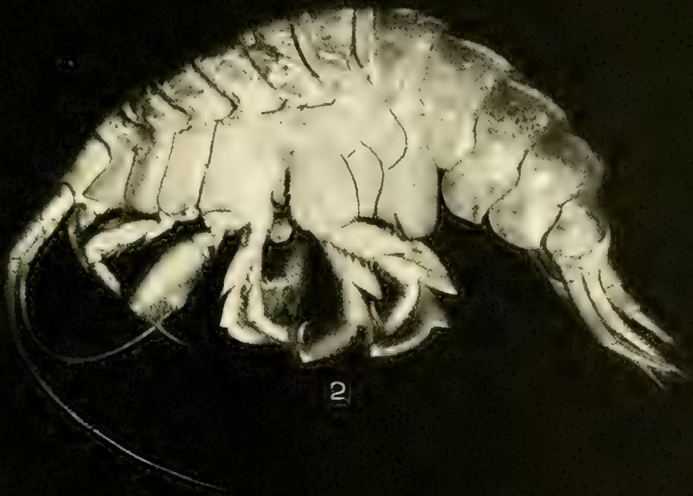
3

1. *Leucothoë spinicarpa.* Grand Manan.
2. *Paradiceros lynceus.* Off Cape Ann, Massachusetts.
3. *Pleustes panoplus.* Grand Manan.

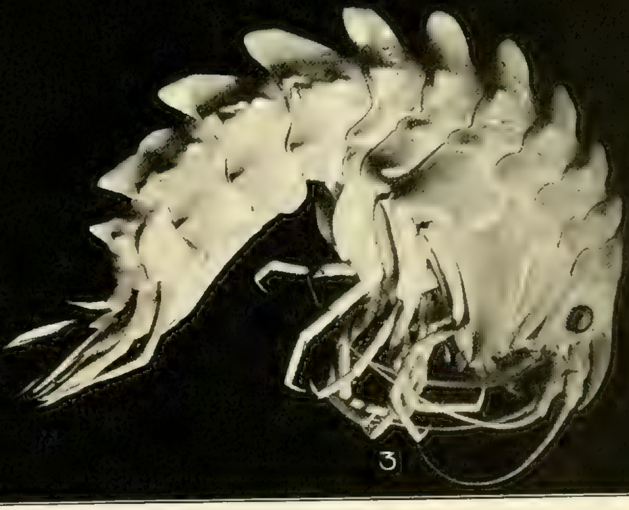
PLATE VIII.



1

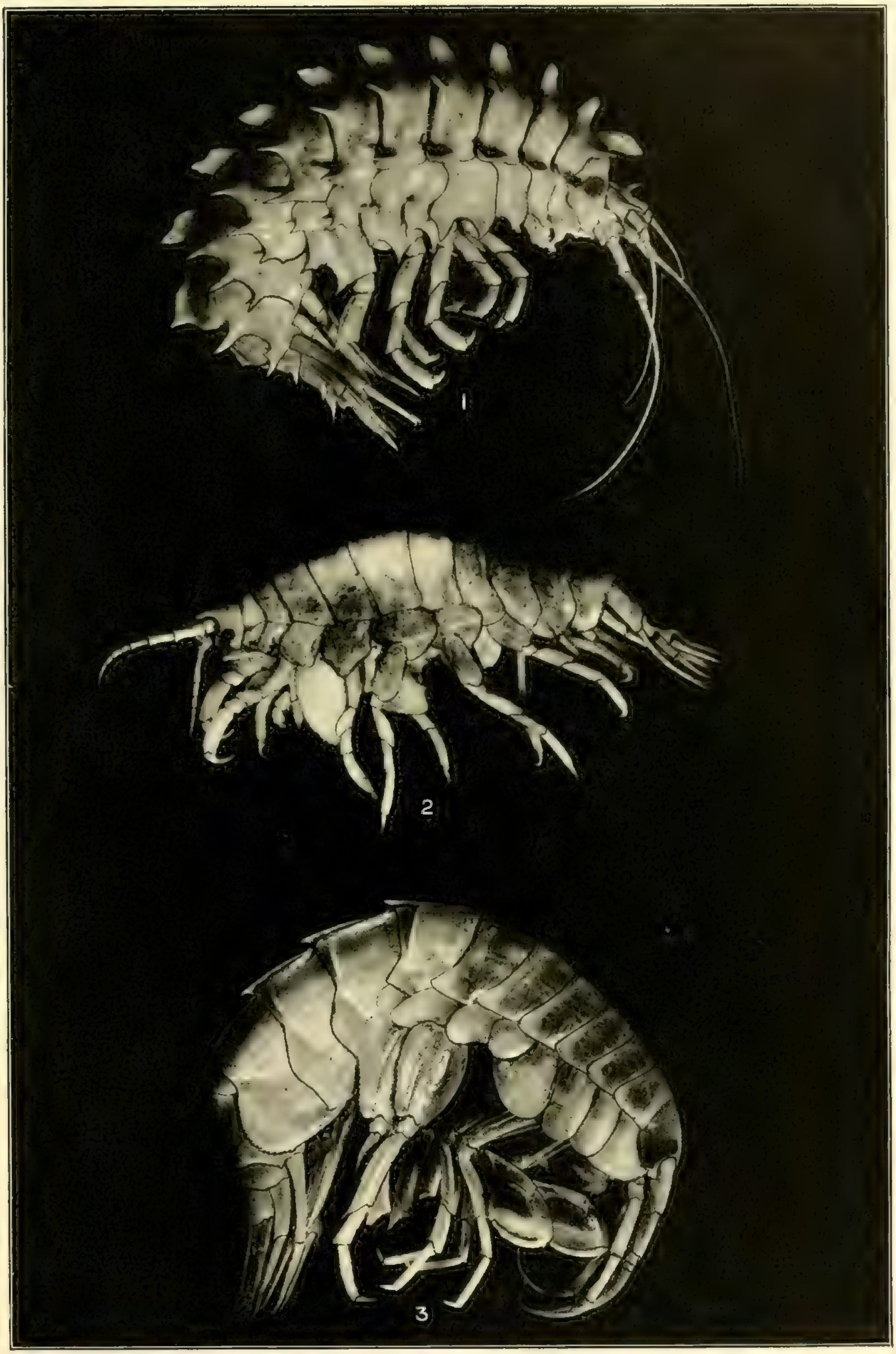


2

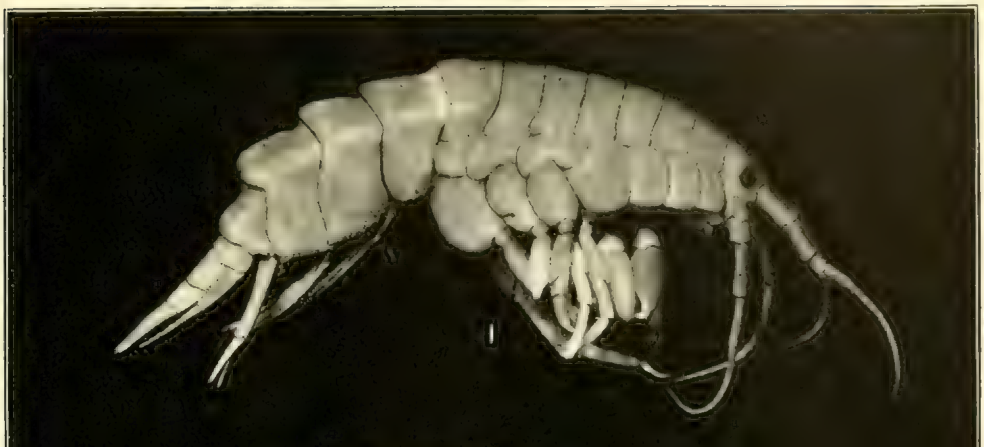


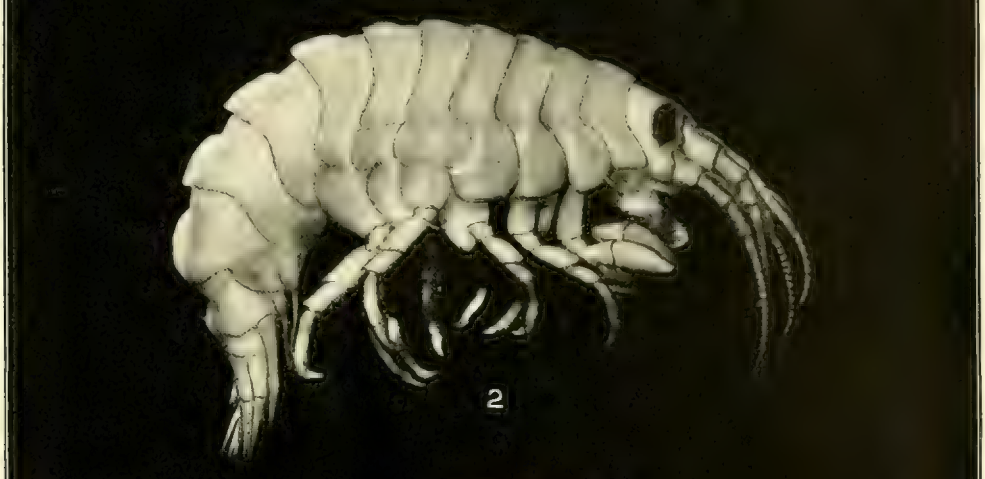
3

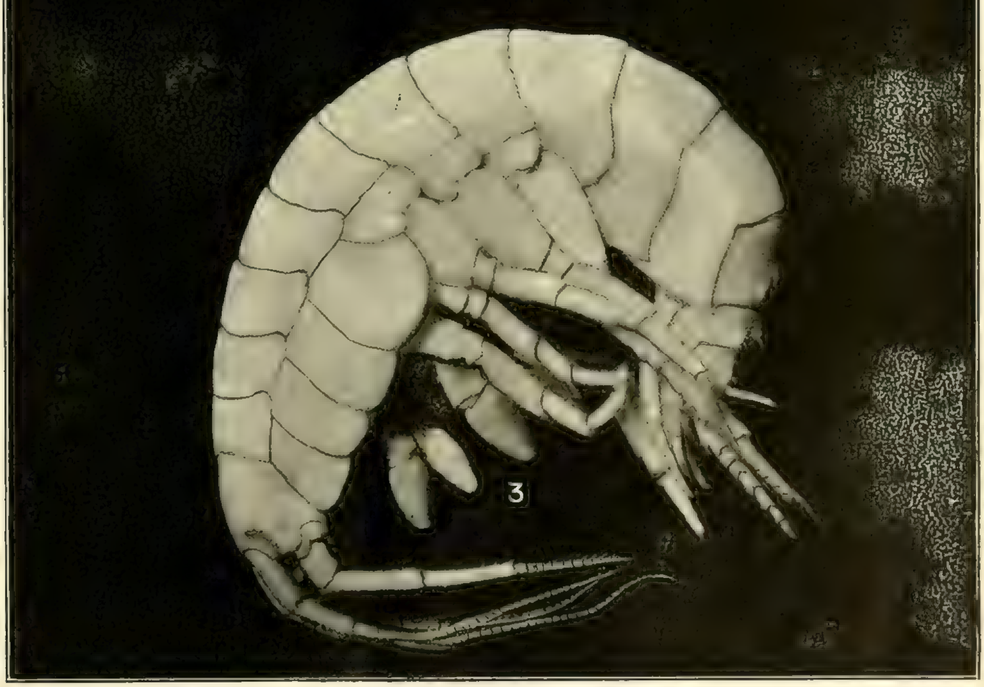
1. *Paramphithoë pulchella.* Grand Manan.
2. *Sympleustes latipes.* Grand Manan.
3. *Epimeria loricata.* Off Head Harbor, Maine.



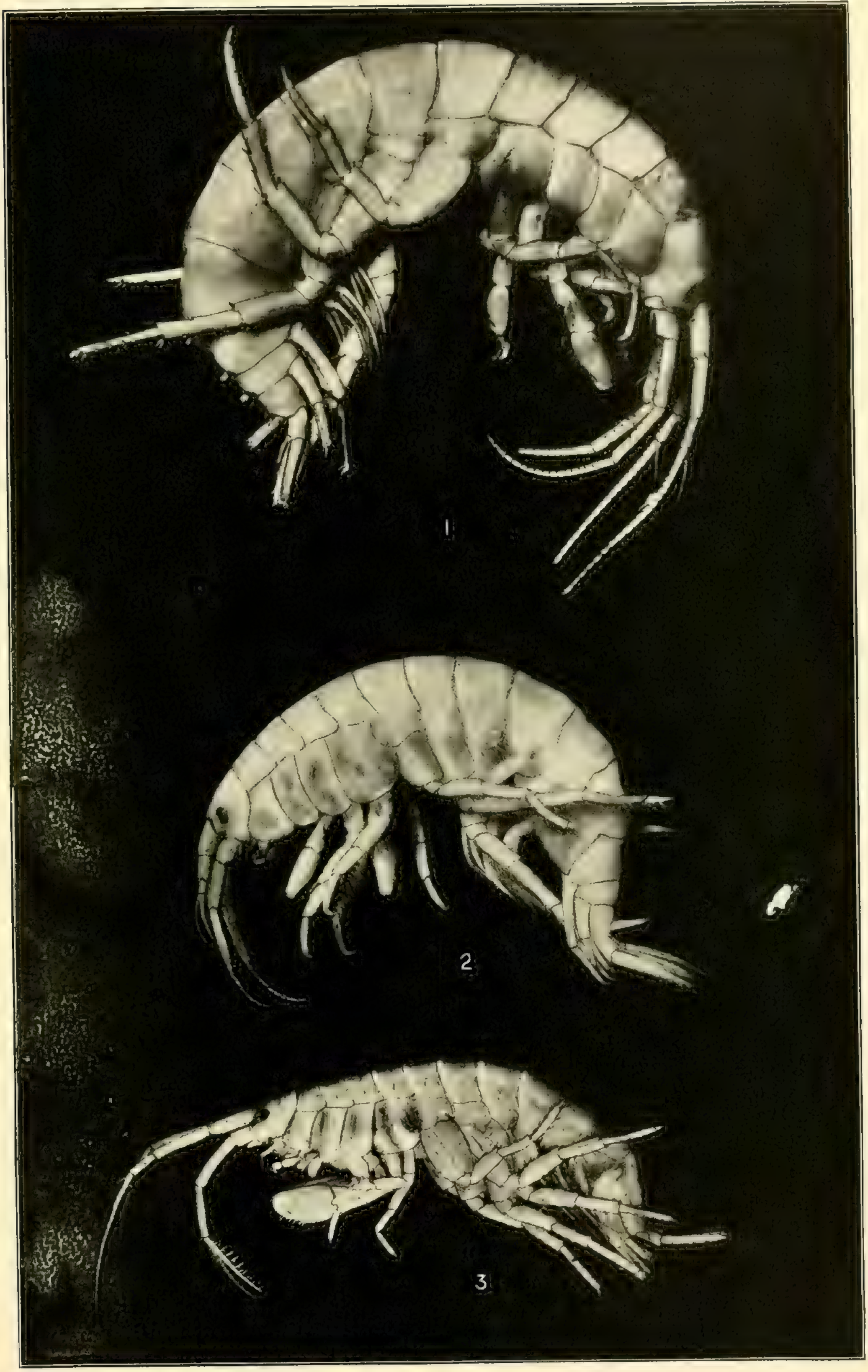
1. *Acanthozoma cuspidata.* Eastport, Me.
2 *Lafystius sturionis.* Woods Hole.
3. *Eusirus cuspidatus.* Grand Manan.



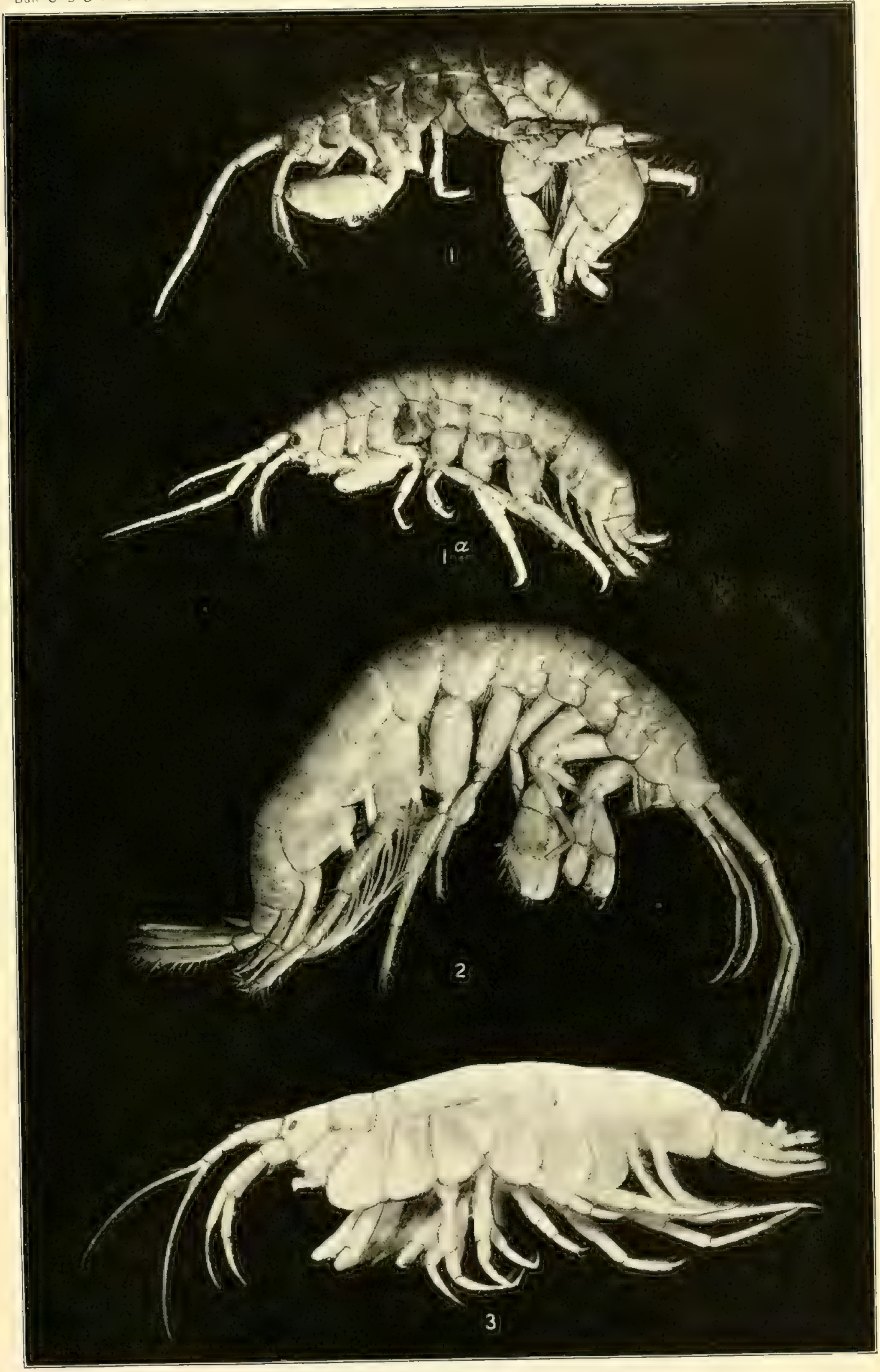




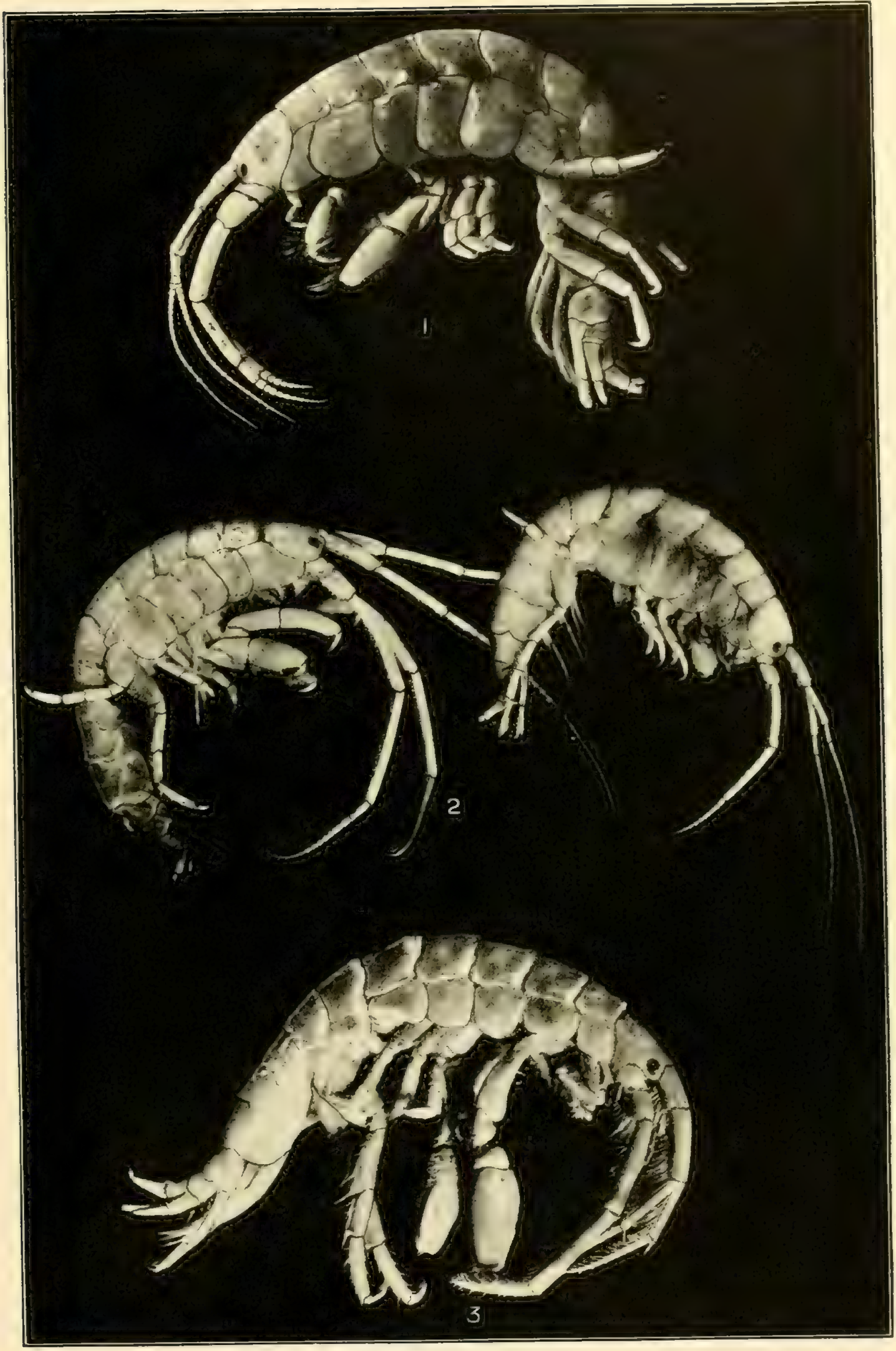
1. *Calliopius lœviusculus.* Vineyard Sound.
2. *Gammarellus angulosus.* Near Woods Hole.
3. *Gammarus locusta.* Near Woods Hole.



1. *Gammarus marinus.* Woods Hole.
2. *Gammarus annulatus.* Vineyard Sound.
3. *Melita nitida.* Woods Hole.



1. *Elasmopus lævis*, male. (1*a*) Female. Woods Hole.
2. *Mæra danæ*. Eastport, Me.
3. *Ptilocheirus pinguis*. Vineyard Sound.



1. *Amphithoë rubricata.* Near Woods Hole.
2. *Amphithoë longimana.* Right figure a female, left a male. Woods Hole.
3. *Ischyrocerus anguipes*, male. Marblehead Beach, Massachusetts.

# INDEX.

Page.

abdominalis, Phryxus 220
abildgaardi, Sparisoma 217
Abudefduf marginatus 245, 256
    saxatilis, examined for entozoa 400
    taurus 245
abyssorum, Hyperoche 464
Acanthobothrium parasitic in fishes 331
Acanthocephala in fishes at Beaufort 330
acanthonotus, Benthopecten, new species 299
Acanthozone cuspidata 491
Acteis macropus 234
    moorei 234
aculeata, Rhachotropis 493
acuminatus, Eques 244
    Myrichthys 233
adscensionis, Epinephelus 239
adspersus, Tautogolabrus 256
aduncum, Distomum, new species 409
Æga symmetrica, new species 211
Ægina pachyderma 58
Æginella longicornis 525
Æginidæ 58
Æquorea albida 52
Æquoreidæ, key to genera 51
affinis, Fierasfer 255
agassizi, Ampelisca 481
agassizii, Corynitis 42
Aglantha conica 56
    digitalis 55
Aglaura hemistoma 55
Aglauridæ, key to genera 55
Ahlia egmontis 233
Alaria, uses 147, 181
alascensis, Pseudarchaster, new species 303
Alaska isopods 209–221
    starfishes, new species 291–320
alaskensis, Holophryxus, new species 221
alata, Bolina 72
alba, Lysianopsis, new species 475
albida, Æquorea 52
albirostris, Corythroichthys 235
Albula vulpes 232
album, Hæmulon 242
Alectis ciliaris 237
Algæ utilized in Japan 133–165, 288
Allorchestes littoralis 472
alosæ, Argulus 121
Alutera schœpfii, entozoa of 401
Amanori 155–160
americana, Amia 239, 256
americanus, Hemitripterus 250
    Menticirrhus 244
    Pseudopleuronectes 256

Page.

Amia americana 239, 256
    sellicauda 239
Ampelisca agassizi 481
    compressa 480
    macrocephala 479
    spinipes 480
Amphipoda, general characters and structure 460
    of southern New England 459–529
Amphithoë longimana 509
    rubricata 510
analis, Lutianus 241
    Pomacentrus 245
Anchorella parasitic in fishes 336
Anchovia brownii 233
    perfasciata 233
Anguilla chrisypa, entozoa of 351
    japonica, cultivation in Japan 274
anguipes, Ischyrocerus 513
angulosus, Gammarellus 508
angustata, Rocinela 214
Anisotremus surinamensis 243
    virginicus 243
annulatus, Gammarus 501
anomalum, Campostoma 226
Anonyx nugax 472
Antennarius multiocellatus 256
    ocellatus 256
Anthobothrium parasitic in fishes 331
Anthocephalum parasitic in fishes 331
Anthomedusæ of Woods Hole 28, 29
Anthophysa formosa 60
Apherusa gracilis, new species 495
apicata, Stomotoca 35
apodus, Lutianus 241
Apomotis cyanellus 227
apua, Mycteroperca venenosa 240
aquilionaris, Etelides 241, 256
Arca granosa, culture in Japan 284
Archosargus probatocephalus 243
    entozoa of 382
arctica, Cyanea 68
arctifrons, Calamus 243
arcuatus, Pomacanthus 248
arenarius, Haustorius 476
Argeia pugettensis 220
Argulus alosæ 121
    catostomi 123
    funduli 125
    in Woods Hole region 115–131
    key to species at Woods Hole 121
    laticauda 127
    list of hosts at Woods Hole 131
    megalops 129

Page.
Argulus parasitic in fishes ........ 115–131, 336
parasitism of ........ 118–121
Ark-shell, culture in Japan ........ 284
Arthrothamnus, uses of ........ 147
Ascaris parasitic in fishes ........ 330
ascensionis, Holocentrus ........ 236
Ascophyllum nodosum, uses of ........ 175
Aspidogaster parasitic in fishes ........ 333
ringens, new species ........ 367, 397
Astropectinidæ ........ 295
Atherina laticeps ........ 235
atlanticus, Tarpon ........ 232
Atolla bairdii ........ 67
verrilli ........ 67
atromaculatus, Semotilus ........ 226
Auchenopterus fasciatus ........ 254
Aulostomus chinensis ........ 234
Aurelia flavidula ........ 67
auricula, Haliclystus ........ 63
aurifrons, Gnathypops, new species ........ 252
aurolineatum, Bathystoma ........ 242
Autonoë smithi, new species ........ 516
Avicula martensii, culture in Japan ........ 283
aya, Lutianus ........ 241
bachei, Nemopsis ........ 41
baculum, Gasterostomum, new species ........ 362
Badderlocks, uses of ........ 181
Bairdiella chrysura, entozoa of ........ 387
bairdii, Atolla ........ 67
bajonado, Calamus ........ 243
Balanus sp., culture in Japan ........ 287
Balistes carolinensis ........ 249
vetula ........ 249
Barnacles, culture in Japan ........ 287
barracuda, Spyhræna ........ 236
bartholomæi, Caranx ........ 237, 256
Batea secunda, new species ........ 499
Bathybiaster pectinatus, new species ........ 295
Bathyluca solaris ........ 66
Bathystoma aurolineatum ........ 242
rimator ........ 242
striatum ........ 242
Beaufort fishes, parasites of ........ 321–428
belliceps, Rocinela ........ 213
Benthopecten acanthonotus, new species ........ 299
Benthopectinidæ ........ 299
Beroe cucumis ........ 73
ovata ........ 73
beryllinus, Cryptotomus ........ 247
bicaudalis, Lactophrys ........ 249
bicophora, Clytia ........ 46
bifasciatum, Thalassoma ........ 246
bipartita, Diphyes ........ 59
bipinnulatus, Elagatis ........ 237
birostris, Manta ........ 232
biserialis, Peribolaster, new species ........ 313
bispinosa, Euthemisto ........ 465
bivittatus, Halichœres ........ 246
Blennius cristatus ........ 255
favosus ........ 254
Boleosoma nigrum ........ 227
Bolina alata ........ 72
Bolinidæ ........ 72
Bomolochus parasitic in fishes ........ 336
Bopyridæ ........ 218
Bopyroides hippolytes ........ 218
Bougainvillia carolinensis ........ 39
gibbsi ........ 40
Bougainvillia superciliaris ........ 40
Brachiella parasitic in fishes ........ 336
brachycephalus, Syngnathus ........ 235
Brachygenys chrysargyreus ........ 242
brasiliensis, Hemiramphus ........ 234
Scorpæna ........ 250
Brevoortia tyrannus, entozoa of ........ 352
Brisinga exilis, new species ........ 318
Brisingidæ ........ 318
brownii, Anchovia ........ 233
Byblis serrata ........ 482
Calamus arctifrons ........ 243
bajonado ........ 243
calamus ........ 243
calamus, Calamus ........ 243
calcarata, Laodicea ........ 43
California starfishes, new species ........ 291–320
californica, Hippasteria, new species ........ 310
Caligus parasitic in fishes ........ 336
Calliobothrium parasitic in fishes ........ 330
Calliopius læviusculus ........ 494
Callyodon cœruleus ........ 248
croicensis ........ 247
evermanni ........ 248
punctulatus ........ 247
vetula ........ 247
campanula, Melicertum ........ 44
campanulifera, Diphyopsis ........ 60
Campostoma anomalum ........ 226
Campylaephora hypneoides, uses of ........ 165
Cannostomæ ........ 65
Cannotidæ, key to genera ........ 45
Cantherines pullus ........ 249
Canthidermis sobaco ........ 256
capistratus, Chætodon ........ 248
Caprella geometrica ........ 526
linearis ........ 526
septentrionalis ........ 527
Caprellidea, key to genera ........ 525
cara, Cupulita ........ 60
Caranx bartholomæi ........ 237, 256
chrysos ........ 237
hippos ........ 237, 256
entozoa of ........ 365
latus ........ 237
Carassius auratus, culture of ........ 266
Carcharhinus milberti, entozoa of ........ 341
obscurus, entozoa of ........ 339
Carcharias lamia ........ 232
Carinogammarus mucronatus ........ 503
carnea, Podocoryne ........ 38
carolinensis, Balistes ........ 249
Bougainvillia ........ 39
carolinus, Trachinotus ........ 238
Carp culture in Japan ........ 273
Carpiodes velifer ........ 226
Carrageen, uses of ........ 165
cataractæ dulcis, Rhinichthys ........ 227
catostomi, Argulus ........ 123
Catostomus commersonii ........ 226
griseus ........ 226
cavalla, Scomberomorus ........ 237
cayorum, Corythroichthys ........ 235
Ogilbia ........ 255
cayuga, Notropis ........ 227
centrata concentrica, Malaclemmys ........ 16
Malaclemmys ........ 14
Centropristes striatus, entozoa of ........ 375

Page.
Cephalacanthus volitans 250
Cephalopholis cruentatus 239
fulvus 239
cephalus, Mugil 235
Cerapus tubularis 517
cerasiformis, Liriope 56
Ceratacanthus schoepfi 249
Cercaria in fishes 333
Cestidæ 73
Cestoda in fishes of Beaufort 331
Cestus veneris 73
Chætodipterus faber 248
entozoa of 400
Chætodon capistratus 248
ocellatus 248
Chanos salmoneus, culture in Formosa 277
Charybdea verrucosa [illegible]
Chelura terebrans 508
Chilomycterus schoepfi 249
entozoa of 403
experiments with 190
chinensis, Aulostomus 234
Chloroscombrus chrysurus 237
Chondracanthus parasitic in fishes 336
Chondrus crispus, uses of 165, 169
ocellatus, uses of 165
Chordaria abietina, uses of 164
Chromis insolatus 544
Chrosomus erythrogaster 226
chrysargyreus, Brachygenys 242
chrysos, Caranx 237
chrysurus, Chloroscombrus 237
Microspathodon 246
Ocyurus 241
cicada, Hoplonyx 474
ciliaris, Alectis 237
Holacanthus 248
ciliatus, Monacanthus 249
cinereum, Xystæma 243
cirratum, Ginglymostoma 232
Cladonemidæ, key to genera 41
cladophora, Gemmaria 42
Clam, razor, culture in Japan 286
clavata, Dipurella 31
Clytia bicophora 46
nolliformis 47
Codium lindenbergii, uses of 164
mucronatum, uses of 164
tomentosum, uses of 164
Codoniidæ, key to genera 29
cœruleus, Callyodon 248
Hepatus 248
Colorado, fishes of Boulder County 223-227
commersonii, Catostomus 226
commissuralis, Obelia 48
compressa, Ampelisca 480
Euthemisto 464
compta, Grubia 510
concentrica, Malaclemmys centrata 16
conica, Aglantha 56
Dipurena 31
Copepoda in fishes of Beaufort 336
Corbicula atrata, culture in Japan 288
cornutus, Notropis 227
Corophium cylindricum 521
corpulentum, Distomum, new species 378, 382
Corynitis agassizii 42
Coryphæna equisetis, entozoa of 373

Page.
Coryphæna hippurus 238
entozoa of 372
Corythroichthys albirostris 235
cayorum 235
Couesius dissimilis 227
crassus, Odontaster, new species 302
cristatus, Blennius 255
croicensis, Callyodon 247
Crossobothrium parasitic in fishes 331
cruciata, Phialis 50
cruentatus, Cephalopholis 239
Priacanthus 241
Cryptopeltaster, new genus 311
lepidonotus, new species 311
Cryptotomus beryllinus 247
Ctenophora of Woods Hole 28, 70
Cubomedusæ 62-64
cucumis, Beroe 73
Culture of marine and fresh-water animals in Japan 257-289
ark-shell 284
barnacles 287
carp 273
eels 271-275
Gastropoda 287
gold-fish 266
gray mullet 275
miscellaneous mollusks 288
oyster 278
pearl oyster 280-284
Pinna 287
razor clam 286
salmon 276
seaweeds 155-181, 288
snapping turtle 260-266
trepang 288
trout 276-277
Cunanthidæ 57
Cunina discoides 57
Cupulita cara 60
curema, Mugil 235
cuspidata, Acanthozone 491
cuspidatus, Eusirus 493
Siphonœcetes 522
Cyanea arctica 68
Cyaneidæ 68
cyanella, Pelagia 70
cyanellus, Apomotis 227
cyanophrys, Psenes 238
Cydippidæ 71
cylindricum, Corophium 521
Cynoscion nebulosus, entozoa of 385
regalis, entozoa of 384
Cyprinus carpio, culture in Japan 273
cypris, Stenothoë, new species 484
Cypselurus furcatus 234
Cystophyllum fusiforme, uses of 163
Dactylocotyle parasitic in fishes 333
Dactylometra quinquecirra 69
Dajidæ 220
danmonensis, Microdeutopus 515
Dasyatis say, entozoa of 346
Decapterus punctatus 237
dentata, Melita 504
dentex, Odontoscion 244
Dexamine thea 498
diademata, Tiaropsis 49
Diamond-back terrapin 1-20
age attained 13

Page.
Diamond-back terrapin, bibliography 4
differences due to age 12
generic synonymy 4
malformations 13
natural history 10
sexual differences 11
species 14
diaphana, Obelia 48
Dibothrium parasitic in fishes 331
Diclidophora parasitic in fishes 333
Digenea simplex, uses of 165
digitalis, Aglantha 55
Diodon holacanthus 249
hystrix 249
diomedæ, Nauphantopsis 66
Diphyes bipartita 59
Diphyopsis campanulifera 60
Diplectrum formosus 240
Diplodus holbrooki 243
entozoa of 383
Dipsacaster eximius, new species 296
Dipurella 31
clavata 31
Dipurena conica 31
strangulata 30
discoides, Cunina 57
Discomedusæ 62, 65
dissimilis, Couesius 227
distinctum, Sparisoma 247
Distomum aduncum, new species 409
corpulentum, new species 378, 382
imparispine, new species 371
inconstans, new species 400
parasitic in fishes 333
pectinatum, new species 366, 389
Doratonotus megalepis 246
dulcis, Rhinichthys cataractæ 227
Dulse, uses of 172
dumerili, Seriola 237
duodecimalis, Eucheilota 46
Dysmorphosa fulgurans 38
Dytaster gilberti, new species 300
Echeneibothrium parasitic in fishes 331
Echinorhynchus parasitic in fishes 330
Ecklonia, uses of 162, 163
Ectopleura ochracea 32
edwardsi, Monoculodes, new species 487
Eel culture in Japan 274
egmontis, Ahlia 233
egregius, Execestides, new species 253
Elacatinus oceanops 252
Elagatis bipinnulatus 237
Elasmopus lævis 507
Elops saurus 232
entozoa of 352
elucens, Syngnathus 235
Enteromorpha, uses of 164
Entozoa of fishes at Beaufort 321
Epenthesis folleata 50
Ephyridæ, key to genera 66
Ephyroides rotaformis 66
Epimeria loricata 491
Epinephelus adscensionis 239
maculosus 239
morio 240
striatus 240
episcopalis, Turris 36
Eques acuminatus 244

Page.
Eques lanceolatus 244
pulcher 244
Eremicaster, new subgenus 293
Ergasilus parasitic in fishes 336
Ericteis kalisheræ 254
Ericthonius minax 519
rubricornis 518
erythrogaster, Chrosomus 226
Etelides aquilionaris 241, 256
Ethcostoma iowæ 227
Etropus crossotus, entozoa of 415
Eucheilota duodecimalis 46
ventricularis 46
Eucinostomus gula 243
entozoa of 383
pseudogula 243
harengulus 243
Eucopidæ, key to genera 45
Euphysa virgulata 33
Eusirus cuspidatus 493
Euthemisto bispinosa 465
compressa 464
Eutima limpida 46
mira 45
evermanni, Callyodon 248
Leuciscus, new species 226
Zoroaster (Myxoderma), new species 317
Eviota personata, new species 251
Execestides egregius, new species 253
exilis, Brisinga, new species 318
eximius, Dipsacaster, new species 296
faber, Chætodipterus 248
falcatus, Trachinotus 237
fasciata, Seriola 237, 256
fasciatus, Auchenopterus 254
favosus, Blennius 254
fecunda, Freyella, new species 319
femorata, Pontoporeia 476
Fierasfer affinis 255
Filaria galeata, new species 344, 374
parasitic in fishes 330
Fish culture in Formosa 277
Japan 266–277
Fish parasites 115–131, 321–428
Fishes collected in Boulder County, Colo 223–227
functions of lateral-line organs in 183–207
of Beaufort, parasites of 321–428
the Tortugas 229–256
Fistularia serrata 235
flavescens, Sparisoma 247
flavidula, Aurelia 67
flavolineatum, Hæmulon 242
floripinnis, Fundulus 227
fœtens, Synodus 233
folleata, Epenthesis 50
Formosa, fish culture in 277
formosa, Anthophysa 60
Tima 47
formosum, Diplectrum 240
Freyella fecunda, new species 319
fuscus, Pomacentrus 244
Fucus, uses of 175
fulgurans, Dysmorphosa 38
fulvocinctus, Halirages 495
fulvus, Cephalopholis 239
funduli, Argulus 125
Fundulus floripinnis 227
heteroclitus, entozoa of 356

Page.
Fundulus heteroclitus, experiments with 190
majalis, entozoa of 355
experiments with 190
zebrinus 227
funebris, Gymnothorax 234
Funori 143
furcatus, Cypselurus 234
furcilliger, Lophaster, new species 312
fusiformis, Obelia 49
Fusus inconstans, cultivation in Japan 288
galba, Hyperia 494
galeata, Filaria, new species 344, 374
Galeichthys milberti, entozoa of 349
Gammarellus angulosus 508
Gammaridea 465
key to genera 466
Gammarus annulatus 501
locusta 500
marinus 502
Gasterostomum baculum, new species 362
gorgon, new species 364
parasitic in fishes 335
Gastropoda, culture in Japan 287
gelatinosa, Obelia 48
Gelidium, uses 137, 171
gemma, Hypoplectrus 240
Gemmaria 41
cladophora 42
geometrica, Caprella 526
Geryonidæ, key to genera 56
gibba, Pterophryne 255, 256
gibbsi, Bougainvillia 40
Gigartina teedii, uses of 165
gilberti, Dytaster, new species 300
Gillellus semicinctus 253
Ginglymostoma cirratum 232
glaber, Sympleustes 490
glaucofrænum, Rhinogobius 251
glesne, Regalecus 255
Gloiopeltis, uses and culture in Japan 144, 288
Glossocodon tenuirostris 57
Glue, seaweed 143
Gnatholepis thompsoni 251
Gnathypops aurifrons, new species 252
maxillosa 252
Gobiomorus gronovii 238
Gold-fish culture in Japan 266
Goniasteridæ 306
Goniasterinæ 306
Gonionemus murbachii 53
goodei, Trachinotus 238
gorgon, Gasterostomum, new species 364
Gracilaria confervoides, uses of 165
gracilis, Apherusa, new species 495
Sphæronectes 61
grandicornis, Scorpæna 250
grata, Lizzia 39
Grateloupia, uses of 165
Gregarines parasitic in fishes 335
griseus, Catostomus 226
Lutianus 241
grœnlandica, Metopa 483
Zygodactyla 52
gronovii, Gobiomorus 238
Grubia compta 510
gryllotalpa, Microdeutopus 514
guacamaia, Pseudoscarus 248
gula, Eucinostomus 243

Page.
guttata, Promicrops 240
Gymnogondrus flabelliformis, uses of 165
Gymnothorax funebris 234
moringa 234
gyrans, Querimana 235
haeckeli, Protiara 34
Hæmulon album 242
flavolineatum 242
macrostomum 242
melanurum 242
parra 242
plumieri 242
sciurus 242
Halichœres bivittatus 246
maculipinna 246
radiatus 246
Haliclystus auricula 63
salpinx 63
Halicyathus lagena 64
Halirages fulvocinctus 495
Halopsis ocellata 51
Harengula humeralis 233
macrophthalma 233
sardina 233
harengulus, Eucinostomus 243
Harpinia plumosa 478
Haustorius arenarius 476
heathi, Hippasteria, new species 309
Hemiramphus brasiliensis 234
hemistoma, Aglaura 55
Hemitripterus americanus 250
Hepatus cœruleus 248
hepatus 248
Heterakis parasitic in fishes 330
Hippasteria californica, new species 310
heathi, new species 309
key to species 308
Hippasteriinæ 308
Hippocampus hudsonius 235, 256
punctulatus 235
stylifer 235
hippolytes, Bopyroides 218
Hippomedon serratus, new species 473
Hippopodius luteus 60
hippos, Caranx 237, 256
hippurus, Coryphæna 238
hispidus, Monacanthus 249, 256
Holacanthus ciliaris 248
tricolor 248
holacanthus, Diodon 249
hölbölli, Phoxocephalus 477
holbrooki, Diplodus 243
holmesi, Tole, new species 216
Holocentrus ascensionis 236
siccifer 236
tortugæ, new species 236
Holophryxus, new genus 220
alaskensis, new species 220
hooperi, Stylactis 41
hoplomystax, Sparisoma 247
Hoplonyx cicada 474
hudsonius, Hippocampus 235, 256
humeralis, Harengula 233
humilis, Periphylla 64
hyacinthina, Periphylla 64
Hybocodon pendula 34
prolifer 33
Hybognathus nuchalis 226

Page.
Hybopsis kentuckiensis ... 227
hyboptera, Lesueuria ... 72
Hydrichthys mirus ... 32
Hydromedusæ of Woods Hole ... 28
Hymenaster quadrispinosus, new species ... 315
Hyperia galba ... 464
    medusarum ... 464
Hyperiidea ... 463
Hyperiidæ, key to genera ... 463
Hyperoche abyssorum ... 464
Hypophthalmichthys molitrix, culture in Formosa ... 277
Hypoplectrus gemma ... 240
    unicolor ... 240
        nigricans ... 240
Hyporhamphus roberti, entozoa of ... 358
    unifasciatus ... 234
Hypsoblennius hentz, entozoa of ... 410
hystrix, Diodon ... 249
Ichthyonema parasitic in fishes ... 330
Idotea ochotensis ... 216
    resecata ... 216
    wosnesenskii ... 216
imparispine, Distomum, new species ... 371
incisor, Kyphosus ... 243
inconstans, Distomum, new species ... 400
inermis, Pontogeneia ... 496
inflatus, Stegocephalus ... 482
insolatus, Chromis ... 244
Iodine from seaweeds ... 160
    industry in Scotland ... 175
iowæ, Etheostoma ... 227
Irish moss, uses of ... 165, 169
irrorata, Unciola ... 520
Ischyrocerus anguipes ... 513
Isinglass, seaweed ... 137, 171
Isopods from Alaska ... 209–221
Japan, culture of ark-shell ... 284
    barnacles ... 287
    carp ... 273
    eels ... 274
    gastropoda ... 287
    gold-fish ... 266
    gray mullet ... 275
    miscellaneous mollusks ... 288
    oysters ... 278
    pearl oyster ... 283
    Pinna ... 287
    razor clam ... 286
    salmon ... 276
    seaweeds ... 133–165, 288
    snapping turtle ... 260
    trepang ... 288
    trout ... 276
  seaweed industries ... 133–165
Jassa marmorata, new species ... 511
Jenkinsia stolifera ... 232
jocu, Lutianus ... 241
jonesii, Perigonimus ... 33
jordani, Pteraster, new species ... 314
kalisheræ, Ericteis ... 254
Kallimenia dentata, uses of ... 165
Kelp, description and uses of ... 173
kentuckiensis, Hybopsis ... 227
Kombu ... 146
Korethrasteridæ ... 313
Kyphosus incisor ... 243
    sectatrix ... 243
        entozoa of ... 383

Page.
Lachnolaimus maximus ... 246
laciniata, Staurostoma ... 43
lactea, Ptychogena ... 45
Lactophrys bicaudalis ... 249
    tricornis ... 249
    trigonus ... 249
    triqueter ... 249
lævigatus, Spheroides ... 249
lævis, Elasmopus ... 507
læviusculus, Calliopus ... 494
Lafystius sturionis ... 492
lagena, Halicyathus ... 64
Lagodon rhomboides ... 243
        entozoa of ... 380
lalandi, Seriola ... 237
lamia, Carcharias ... 232
Laminaria, uses of ... 147
lanceolatus, Equetus ... 241
languida, Oceania ... 50
Laodicea calcarata ... 43
Lateral-line organs in fishes, functions of ... 183–207
laticauda, Argulus ... 127
laticeps, Atherina ... 235
latipes, Sympleustes ... 490
latus, Caránx ... 237
Laver utilized in Japan ... 155
        United States ... 173
Lecanicephalum parasitic in fishes ... 331
Lecanocephalus parasitic in fishes ... 331
leidyi, Mnemiopsis ... 72
Leiostomus xanthurus, entozoa of ... 391
lepidonotus, Cryptopeltaster, new species ... 311
Lepisoma nuchipinne ... 254
Leptecheneis naucrates ... 254
Leptocephalus conger, entozoa of ... 351
leptocerama, Tosia, new species ... 306
Leptomedusæ of Woods Hole ... 29, 42
Lernæonema parasitic in fishes ... 336
Lernanthropus parasitic in fishes ... 336
Lesueuria hyboptera ... 72
Lesueuriidæ ... 72
Leuciscus evermanni, new species ... 226
leucostictus, Pomacentrus ... 245
Leucothoë spinicarpa ... 486
limpida, Eutima ... 46
linearis, Caprella ... 526
Linerges mercurius ... 67
Linergidæ ... 67
linnæana, Porpita ... 59
Liriope cerasiformis ... 56
    scutigera ... 56
littoralis, Allorchestes ... 472
    Malaclemmys, new species ... 18
    Menticirrhus ... 244
Lizzia grata ... 39
Lobata ... 72
locusta, Gammarus ... 500
longicornis, Æginella ... 525
    Talorchestia ... 468
longimana, Amphithoë ... 509
Lophaster furcilliger, new species ... 312
Lopholatilus chamæleonticeps, blood-vascular system ... 87–114
        osteology ... 81–86
        relations ... 81–86
Lophopsetta maculata, entozoa of ... 414
loricata, Epimeria ... 491
Lucernaria quadricornis ... 63

| | Page. |
|---|---|
| Lucernariidæ, key to genera | 63 |
| luteus, Hippopodius | 60 |
| Lutianus analis | 241 |
| apodus | 241 |
| aya | 241 |
| griseus | 241 |
| jocu | 241 |
| synagris | 241 |
| lutrensis, Notropis | 227 |
| lynceus, Parœdiceros | 487 |
| Lysianopsis alba, new species | 475 |
| new genus | 475 |
| mackayi, Syngnathus | 250 |
| macrocephala, Ampelisca | 479 |
| macrognathus, Opisthognathus | 252 |
| macrophthalma, Harengula | 233 |
| macropus, Acteis | 254 |
| macrospilota, Malaclemmys, new species | 16–17 |
| macrostomum, Hæmulon | 242 |
| Mactra sulcatoria, culture in Japan | 288 |
| maculatus, Psenes | 256 |
| Pseudupeneus | 243 |
| scomberomorus | 237 |
| maculipinna, Halichœres | 246 |
| maculosus, Epinephelus | 239 |
| Malaclemmys, age attained | 13 |
| bibliography | 4 |
| centrata | 14 |
| concentrica | 16 |
| differences due to age | 12 |
| discussion of species | 14 |
| general natural history | 10 |
| generic synonymy and diagnoses | 4 |
| littoralis, new species | 18 |
| macrospilota, new species | 16 |
| malformations | 13 |
| pileata | 17 |
| revision of | 1–20 |
| sexual differences | 11 |
| Manta birostris | 232 |
| Mapo soporator | 251 |
| Margelidæ, key to genera | 37 |
| marginatus, Abudefduf | 245, 256 |
| marinus, Gammarus | 502 |
| marmorata, Jassa, new species | 511 |
| martinicus, Pseudupeneus | 243 |
| maxillosa, Gnathypops | 252 |
| maximus, Lachnolaimus | 246 |
| Mediaster tenellus, new species | 307 |
| Mediasterinæ | 307 |
| medusarum, Hyperia | 464 |
| Medusæ, account of | 26 |
| Medusæ of the Woods Hole region | 21–79 |
| megalepis, Doratonotus | 246 |
| megalophthalma, Talorchestia | 468 |
| megalops, Argulus | 129 |
| melanurum, Hæmulon | 242 |
| Melicertum campanula | 44 |
| Melita dentata | 504 |
| nitida | 505 |
| parvimana, new species | 506 |
| Menidia menidia, entozoa of | 360 |
| Menticirrhus americanus | 244 |
| entozoa of | 398 |
| littoralis | 244 |
| Mertensia ovum | 71 |
| Mertensiidæ | 71 |
| Mesogloia decipiens, uses of | 165 |

| | Page. |
|---|---|
| Metopa grœnlandica | 483 |
| Microcotyle parasitic in fishes | 335 |
| Microdeutopus danmonensis | 515 |
| gryllotalpa | 514 |
| Micropogon undulatus, entozoa of | 394 |
| Micropterus salmoides | 227 |
| Microspathodon chrysurus | 246 |
| Mimaster swifti, new species | 301 |
| Mimasterinæ | 301 |
| minax, Ericthonius | 519 |
| minuta, Stenothoë, new species | 485 |
| Mionorus puncticulatus | 239 |
| mira, Eutima | 45 |
| mirabilis, Syncoryne | 30 |
| mirus, Hydrichthys | 32 |
| Mnemiidæ | 72 |
| Mnemiopsis leidyi | 72 |
| Monacanthus ciliatus | 249 |
| hispidus | 249, 256 |
| entozoa of | 401 |
| Monoculodes edwardsi, new species | 487 |
| Monostomum parasitic in fishes | 335 |
| moorei, Acteis | 254 |
| morio, Epinephelus | 240 |
| moringa, Gymnothorax | 234 |
| mucronatus, Carinogammarus | 503 |
| Mugil cephalus | 235 |
| entozoa of | 361 |
| curema | 235 |
| entozoa of | 360 |
| oeur, cultivation in Japan | 275 |
| mulleri, Pempheris | 238 |
| Mullet culture in Japan | 275 |
| multiocellatus, Antennarius | 256 |
| murbachii, Gonionemus | 53 |
| Mustelus canis, experiments with | 190 |
| mutica, Velella | 59 |
| Mycteroperca venenosa apua | 240 |
| myops, Trachinocephalus | 233 |
| Myrichthys acuminatus | 233 |
| Myxobolus parasitic in fishes | 335 |
| Myxoderma, new subgenus | 316 |
| Narcomedusæ of Woods Hole | 29, 57 |
| narinari, Stoasodon | 232 |
| naucrates, Leptecheneis | 254 |
| Nauphantopsis diomedæ | 66 |
| Nausithoe punctata | 66 |
| Nemalion, uses of | 165 |
| Nematoda in fishes of Beaufort | 330 |
| Nemopsis bachei | 41 |
| Nereocystis lütkeana, description and uses | 173 |
| nigricans, Hypoplectrus unicolor | 240 |
| nigrum, Boleosoma | 227 |
| niphobles, Sparisoma | 247 |
| nitida, Melita | 505 |
| Podoceropsis | 524 |
| nitidum, Thalassoma | 246 |
| nolliformis, Clytia | 47 |
| Nontentaculata | 73 |
| Notropis cayuga | 227 |
| cornutus | 227 |
| lutrensis | 227 |
| piptolepis | 227 |
| scylla | 227 |
| Novaculichthys rosipes | 247 |
| nuchalis, Hybognathus | 226 |
| nuchipinne, Lepisoma | 254 |
| nugax, Anonyx | 472 |

Page.
nutricula, Turritopsis 37
Obelia 17
  commissuralis 48
  diaphana 48
  fusiformis 49
  gelatinosa 48
  pyriformis 49
Oceania 49
  languida 50
  singularis 50
oceanops, Elacatinus 252
ocellata, Halopsis 51
ocellatus, Antennarius 256
  Chætodon 248
  Platophrys 255
ochotensis, Idotea 216
ochracea, Ectopleura 32
Ocyurus chrysurus 241
Odontaster crassus, new species 302
Odontasteridæ 302
Odontoscion dentex 244
Ogilbia cayorum 256
Oligoplites saurus 237
Onchobothrium parasitic in fishes 331
Oncorhynchus, cultivation in Japan 276
Oniscidæ 217
ophiurus, Zoroaster, new species 315
Opisthognathus macrognathus 252
Opsanus tau, entozoa of 406
  experiments with 190
orbignianus, Parexocœtus 234
Orchestia palustris 471
Orchistoma tentaculata 44
oregonensis, Sphæroma 216
Organs, lateral-line, of fishes 183–207
ornata, Phacellophora 68
  Willia 40
Orthopristis chrysopterus, entozoa of 376
Ostrea cucullata, culture in Japan 278
Otobothrium parasitic in fishes 331
ovata, Beroe 73
ovum, Mertensia 71
Oxylabrax undecimalis 239
Oyster culture in Japan 278
  pearl, culture in Japan 283
pachyderma, Ægina 58
palometa, Trachinotus 237
palustris, Orchestia 471
Pandarus parasitic in fishes 336
panoplus, Pleustes 488
Paralichthys albiguttus, entozoa of 411
  dentatus, entozoa of 410
Paramphithoë pulchella 489
Paraphoxus spinosus, new species 477
Parasites of fishes 115–131, 321–428
Paratænia parasitic in fishes 331
Parexocœtus orbignianus 234
Paredliceros lynceus 487
parra, Hæmulon 242
paru, Peprilus 256
  Pomacanthus 248
parvimana, Melita, new species 506
Pearl oyster, culture in Japan 283
pectinatum, Distomum, new species 366, 389
pectinatus, Bathybiaster, new species 295
Peganthidæ 58
Pelagia cyanella 70
pelagica, Physalia 61
Pelagiidæ, key to genera 69
Pempheris mulleri 238
pendula, Hybocodon 34
penicillatus, Persephonaster, new species 297
Pennaria tiarella 32
Peprilus paru 256
perfasciata, Anchovia 233
Peribolaster biserialis, new species 313
Perigonimus jonesii 33
Periphylla humilis 64
  hyacinthina 64
  peronii 64
Peromedusæ 62, 64
peronii, Periphylla 64
Persephonaster penicillatus, new species 297
personata, Eviota, new species 251
Petasidæ 53
Phacellophora ornata 68
Phenacobius scopifer 227
Phialis cruciata 50
Phoreiobothrium parasitic in fishes 331
Phoxocephalus holbolli 477
Phronima sedentaria 465
Phronimidæ 465
Phryxus abdominalis 220
Phyllitis fascia, uses of 164
Phyllobothrium parasitic in fishes 331
Phylloderma sacrum, uses of 164
Physalia pelagica 61
pileata, Malaclemmys 17
pileus, Pleurobrachia 71
Pimephales promelas 226
pinguis, Ptilocheirus 522
  Tryphosa 473
Pinna japonica, culture in Japan 287
piptolepis, Notropis 227
planifrons, Pomacentrus 245
Platophrys ocellatus 255
Pleurobrachia pileus 71
Pleurobrachiidæ 71
Pleustes panoplus 488
plicatum, Rhynchobothrium, new species 345
plumieri, Hæmulon 242
  Scorpæna 250
plumosa, Harpinia 478
Plutonasteridæ 300
Podoceropsis nitida 524
Podocoryne carnea 38
Pollachius virens 256
Pomacanthus arcuatus 248
  fuscus 244
  leucostictus 245
  paru 248
  planifrons 245
Pomacentrus analis 245
Pomatomus saltatrix, entozoa of 368
Pomoxis sparoides 227
Pontoporeia femorata 476
Pontogeneia inermis 496
Porcellanaster tenebrarius, new species 293
Porcellanasteridæ 293
Porcellio scaber 217
Porphyra, uses and culture 155, 173, 288
Porpita linneana 59
Priacanthus cruentatus 241
Prionotus roseus 250
  scitulus, entozoa of 404
  tribulus 250

Page.
Prionotus tribulus, entozoa of 404
probatocephalus, Archosargus 243
producta, Syncoryne 30
prolifer, Hybocodon 33
promelas, Pimephales 226
Promicrops guttata 240
propodialis, Rocinela, new species 214
Protiara 34
haeckeli 34
Protozoa in fishes of Beaufort 335
Psenes cyanophrys 238
maculatus 256
Pseudarchaster alascensis, new species 303
pusillus, new species 304
Pseudarchasteridæ 303
pseudogula, Eucinostomus 243
Pseudopleuronectes americanus 256
experiments with 190
Pseudoscarus guacamaia 248
Pseudupeneus maculatus 243
martinicus 243
psittacus, Xyrichthys 247
Pteraster jordani, new species 314
Pterasteridæ 314
Pterophryne gibba 255, 256
Pteroplatea maclura, entozoa of 348
Ptilocheirus pinguis 522
Ptychogena lactea 45
pugettensis, Argeia 220
pulchella, Paramphithoë 489
pulcher, Eques 244
pullus, Cantherines 249
punctata, Nausithoe 66
punctatus, Decapterus 237
puncticulatus, Mionorus 239
punctulatus, Callyodon 247
Hippocampus 235
pusillus, Pseudarchaster, new species 304
pyriformis, Obelia 49
quadricornis, Lucernaria 63
quadrispinosus, Hymenaster, new species 315
Querimana gyrans 235
quinquecirra, Dactylometra 69
Rachycentron canadus, entozoa of 370
radians, Sparisoma 247
radiatus, Halichœres 246
Raja erinacea, experiments with 190
lævis, entozoa of 346
Rapana bezoar, cultivation in Japan 288
raphidoma, Tylosurus 234
Razor clam, culture in Japan 286
Regalecus glesne 255
resecata, Idotea 216
reticulata, Syncoryne 30
Rhachotropis aculeata 493
Rhegmatodes tenuis 51
Rhinebothrium parasitic in fishes 332
Rhinichthys cataractæ dulcis 227
Rhinogobius glaucofrænum 251
tortugæ 251
Rhizostomæ 65
Rhodymenia, uses of 172
rhomboides, Lagodon 243
Rhopalonema typicum 54
Rhynchobothrium parasitic in fishes 331
plicatum, new species 345
rimator, Bathystoma 242
ringens, Aspidogaster, new species 367, 397

Page.
Rocinela angustata 914
belliceps 213
propodialis, new species 214
roseus, Prionotus 250
rosipes, Novaculichthys 247
rotaformis, Ephyroides 66
rubricata, Amphithoë 510
rubricornis, Ericthonius 518
rugosa, Stomotoca 35
Rypticus saponaceus 241
sacculatus, Zoroaster (Myxoderma), new species 316
salmoides, Micropterus 227
Salmon and trout culture in Japan 276
salpinx, Haliclystus 63
saponaceus, Rypticus 241
Sarcodia, uses of 165
sardina, Harengula 233
Sargassum, uses of 165
saurus, Elops 232
Oligoplites 237
scaber, Porcellio 217
Sciænops ocellatus, entozoa of 390
Schizymenia edulis, uses 180
schoepfi, Ceratacanthus 249
Chilomycterus 190, 249
sciurus, Hæmulon 242
Scolex parasitic in fishes 331
Scoliodon terræ-novæ 232
entozoa of 342
Scomberomorus cavalla 237
maculatus 237
entozoa of 362
regalis, entozoa of 362
scopifer, Phenacobius 227
Scorpæna brasiliensis 250
grandicornis 250
plumieri 250
scovelli, Syngnathus 235
scutigera, Liriope 56
scylla, Notropis 227
Scyphomedusæ of Woods Hole 28, 61
Sea lettuce, uses of 181
Seaweed glue 143
industries of Japan 133–165
iodine 160
isinglass 137, 171
Seaweeds utilized in the United States 167–181
sectatrix, Kyphosus 243
secunda, Batea, new species 499
sedentaria, Phronima 465
Selene vomer 237
entozoa of 365
sellicauda, Amia 239
semicinctus, Gillellus 253
Semostomæ 65
Semotilus atromaculatus 226
septentrionalis, Caprella 527
Seriola dumerili 237
fasciata 237, 256
lalandi 237
entozoa of 363
serrata, Byblis 482
Fistularia 235
serratus, Hippomedon, new species 473
siccifer, Holocentrus 236
singularis, Oceania 50
Siphonœcetes cuspidatus 522
Siphonophora of Woods Hole 29, 59

Page.
Siphostoma fuscum, entozoa of 359
smithi, Autonoë, new species 516
Snapping turtle, culture in Japan 260
sobaco, Canthidermis 256
solaris, Bathyluca 66
Solasteridæ 312
Solecurtus constricta, culture in Japan 286
Solmaridæ 58
Solmaris tetranema 58
soporator, Mapo 251
Sparisoma abildgaardi 247
    distinctum 247
    flavescens 247
    hoplomystax 247
    niphobles 247
    radians 247
    viride 247
    xystrodon 247
sparoides, Pomoxis 227
spengleri, Spheroides 249
Sphæroma oregonensis 216
Sphæronectes gracilis 61
Spheroides lævigatus 249
    maculatus, entozoa of 402
    spengleri 249
    testudineus 249
spinicarpa, Leucothoë 486
spinipes, Ampelisca 480
spinosus, Paraphoxus, new species 477
Spongiobothrium parasitic in fishes 333
Sphyræna barracuda 236
    borealis, entozoa of 361
Sphyrna tiburo 232
    entozoa of 344
    zygæna 232
Starfishes, new species from California and Alaska 291–320
Stauromedusæ 62
Staurostoma laciniata 43
Stegocephalus inflatus 482
Stenotomus chrysops, experiments with 190
Stenothoë cypris, new species 484
    minuta, new species 485
Stichopus japonicus, culture in Japan 288
Stoasodon narinari 232
Stolephorus brownii, entozoa of 353
stolifera, Jenkinsia 232
Stomobrachium tentaculatum 51
Stomotoca 35
    apicata 35
    rugosa 35
strangulata, Dipurena 30
striatum, Bathystoma 242
striatus, Epinephelus 240
sturionis, Lafystius 492
Stylactis hooperi 41
stylifer, Hippocampus 235
superciliaris, Bougainvillia 40
surinamensis, Anisotremus 243
swifti, Mimaster, new species 301
symmetrica, Æga, new species 211
Symphurus plagiusa, entozoa of 415
Sympleustes latipes 490
    glaber 490
synagris, Lutianus 241
Synbothrium, parasitic in fishes 333
Syncoryne mirabilis 30
    producta 30
    reticulata 30

Page.
Syngnathus brachycephalus 235
    elucens 235
    mackayi 235
    scovelli 235
Synodus fœtens 233
    entozoa of 353
Tænia, parasitic in fishes 333
Talorchestia longicornis 468
    megalophthalma 469
Tapes philippinarum, culture in Japan 288
Tarpon atlanticus 232
taurus, Abudefduf 245
Tautogolabrus adspersus 256
tenellus, Mediaster, new species 307
tenebrarius, Porcellanaster (Eremicaster), new species 293
Tentaculata 71
tentaculata, Orchistoma 44
tentaculatum, Stomobrachium 51
tenuirostris, Glossocodon 57
tenuis, Rhegmatodes 51
    Urophycis 256
terebrans, Chelura 508
terræ novæ, Scoliodon 232
Terrapin, Carolina 14
    Chesapeake 16
    diamond-back 1–20
    Florida 16
    Louisiana 17
    new species of 18
testudineus, Spheroides 249
tetranema, Solmaris 58
Tetrarhynchus, parasitic in fishes 333
Thalassoma bifasciatum 246
    nitidum 246
Thaumantiidæ, key to genera 43
thea, Dexamine 498
thompsoni, Gnatholepis 251
tiarella, Pennaria 32
Tiaridæ, key to genera 34
Tiaropsis diademata 49
tiburo, Sphyrna 232
Tile-fish, blood-vascular system 87–114
    osteology and immediate relations 81–86
Tima formosa 47
Tole holmesi, new species 216
tortugæ, Holocentrus, new species 236
    Rhinogobius 251
Tortugas fishes 229–256
Tosia leptocerama, new species 306
Trachinocephalus myops 233
Trachinotus carolinus 238
    entozoa of 366
    falcatus 237
    goodei 238
    palometa 237
Trachomedusæ of Woods Hole 29, 53
Trachynemidæ, key to genera 54
Trematoda in fishes of Beaufort 333
tribulus, Prionotus 250
tricolor, Holacanthus 248
tricornis, Lactophrys 249
trigonus, Lactophrys 249
Trionyx japonicus, culture in Japan 260
triqueter, Lactophrys 249
Trout and salmon culture in Japan 276
Tryphosa pinguis 473
tubularis, Cerapus 517
Turris episcopalis 36

Page.
Turris vesicaria 36
Turritopsis nutricula 37
Turtles, culture in Japan 260
  revision of the genus Malaclemmys 1-20
Tylosurus caribbæus, entozoa of 358
  marinus, entozoa of 356
  raphidoma 234
    entozoa of 357
typicum, Rhopalonema 54
Ulmaridæ, key to genera 67
Ulva lactuca, uses of 164
  latissima, uses of 181
Undaria pinnatifida, uses of 164
Uniola irrorata 520
undecimalis, Oxylabrax 239
unicolor, Hypoplectrus 240
  nigricans, Hypoplectrus 240
unifasciatus, Hyporhamphus 234
Upeneus maculatus, entozoa of 361
Urophycis tenuis 256
Utilization of seaweeds in the United States 167-181
Velella mutica 59
velifer, Carpiodes 226
venenosa apua, Mycteroperca 240
veneris, Cestus 73

Page.
ventricularis, Eucheilota 46
verrilli, Atolla 67
verrucosa, Charybdea 65
vesicaria, Turris 36
vetula, Balistes 249
  Callyodon 247
virens Pollachius 256
virginicus, Anisotremus 243
virgulata, Euphysa 33
viride, Sparisoma 247
volitans, Cephalacanthus 250
vulpes, Albula 232
Willia ornata 40
Woods Hole medusæ 21-79
wosnesenskii, Idotea 216
Xyrichthys psittacus 247
Xystæma cinereum 243
xystrodon, Sparisoma 247
zebrinus, Fundulus 227
Zoroaster (Myxoderma) evermanni, new species 317
  sacculatus, new species 316
  ophiurus, new species 315
Zoroasteridæ 315
zygæna, Sphyrna 232
Zygodactyla grœnlandica 52

◆

SMITHSONIAN INSTITUTION LIBRARIES

RARIES SMITHSONIAN INSTITUTION INSTITUTION SMITHSONIAN LIBRARIES LIBRARIES SMI
INSTITU SMITHSONIAN LIBRARIES LIBRARIES SMITHSONIAN INSTITUTION INSTITUTION NAI
RARIES SMITHSONIAN INSTITUTION INSTITUTION SMITHSONIAN LIBRARIES LIBRARIES SMI
INSTITU SMITHSONIAN LIBRARIES LIBRARIES SMITHSONIAN INSTITUTION INSTITUTION NAI
RARIES SMITHSONIAN INSTITUTION INSTITUTION SMITHSONIAN LIBRARIES LIBRARIES SMI
INSTITU SMITHSONIAN LIBRARIES LIBRARIES SMITHSONIAN INSTITUTION INSTITUTION NAI
RARIES SMITHSONIAN INSTITUTION INSTITUTION SMITHSONIAN LIBRARIES LIBRARIES SMI
INSTITU SMITHSONIAN LIBRARIES LIBRARIES SMITHSONIAN INSTITUTION INSTITUTION NAI
RARIES SMITHSONIAN INSTITUTION INSTITUTION SMITHSONIAN LIBRARIES LIBRARIES SMI
INSTITU SMITHSONIAN LIBRARIES LIBRARIES SMITHSONIAN INSTITUTION INSTITUTION NAI
SMITHSONIAN INSTITUTION INSTITUTION SMITHSONIAN LIBRARIES LIBRARIES SM

BOUND BY
HM

SMITHSONIAN INSTITUTION LIBRARIES
3 9088 01017 7020